



# Experience and projects with PRISM at KNMI

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## Overview

- Description of TM5
- Coupling TM5 to ECHAM within the PRISM system:
  - Adapting TM5
  - Adapting ECHAM
  - Some specifications of the coupled system.
- GEMS: Coupling TM5 to IFS with OASIS4
- The future & distant future.
- Conclusions.





## TM5 – Tracer Model version 5

- Global offline CTM
- History:
  - TM2 (Martin Heimann, MPI-Meteorology),
  - TM3 (IMAU, KNMI, CWI) :
    - + hybrid sigma-pressure levels
  - TM5 (IMAU, KNMI, JRC)
    - + parallel
    - + zooming





## Physics in TM5

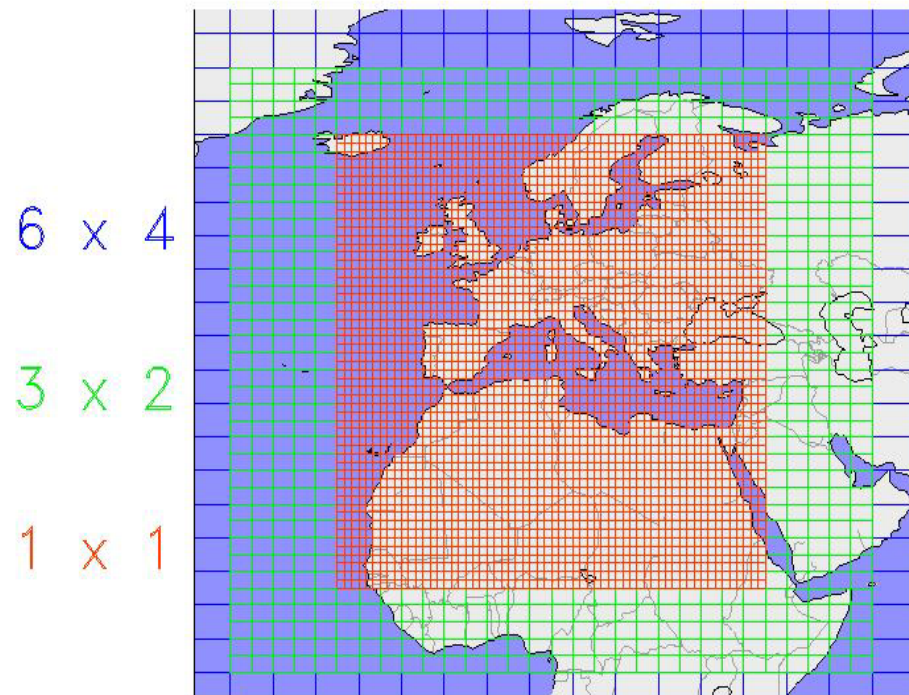
- Advection: slopes [Russel and Lerner, 1987] or second moments [Prather, 1989]
- Convection: [Tiedke, 1987]
- Turbulent mixing: [Holtslag and Boville, 1993, Voegelesang and Holtslag, 1996]
- Chemistry schemes:
  - Troposphere, based on CBM-IV (25 layers, 26 transp.tracers)
  - Stratosphere-troposphere (33 layers, 44 transp.tracers)
  - Parameterized ozone scheme for data assimilation
  - Tracers: radon, SF6, methane, CO2, ..



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## Horizontal zooming

- Arbitrary zoom regions
- Two-way nesting
- Typical runs with 3 levels of nesting



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## Parallelization

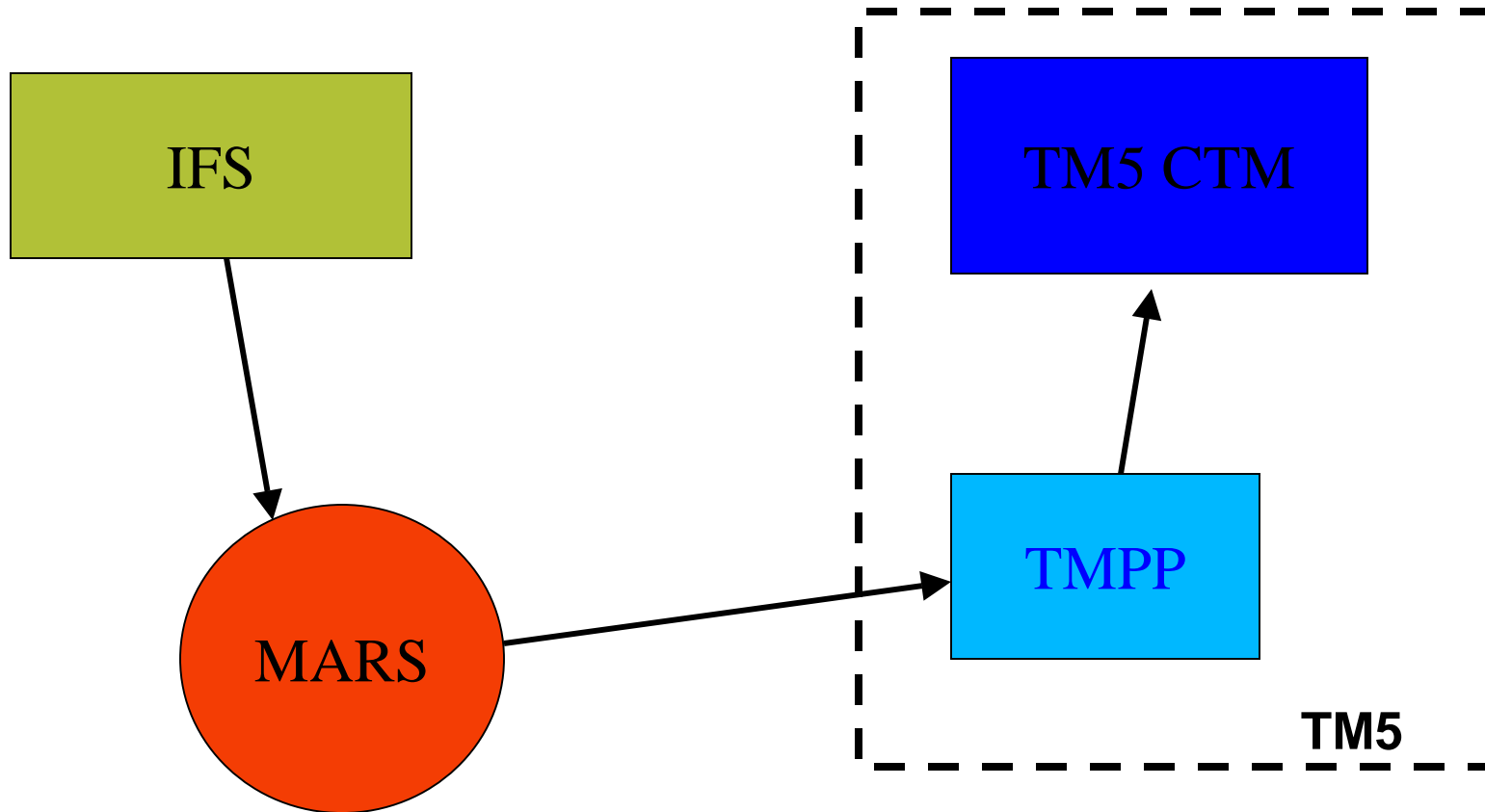
- Advection, diffusion, etc: parallel over tracers
- Chemistry: parallel over layers

--> limitation to 16-32 processors for reasonable speedup

--> typical experiments run on 9 processors



“Classical” TM needs Meteo preprocessing



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## TMPP (TM PreProcessor):

- Input from MARS:
  - Log.surf.pressure, vorticity, divergence
  - Temperature, humidity
  - Cloud fields
  - Surface fields
- Horizontal Interpolation: spectral/gg -> lat/lon
- Merging of vertical layers
- Output:
  - Mass fluxes through grid box boundaries
  - Gridded temperature, humidity, etc

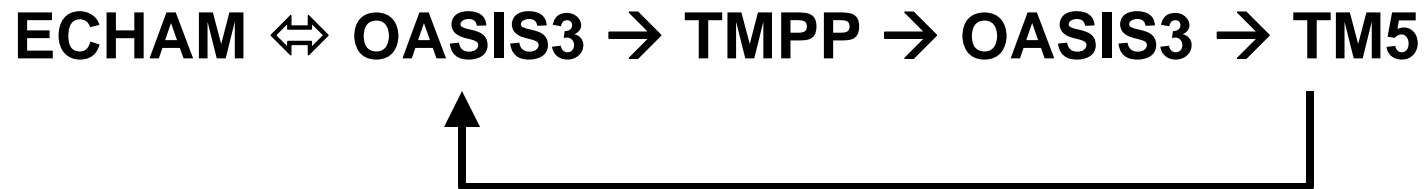


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## Adapting TM5

To couple TM5 to ECHAM, the 'simple' PRISM-adaptation would – in theory – have looked like this:



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However, to keep things simpler, a different route was chosen:

- Interpolation routines from TMPP were integrated into TM5
- The “PRISM” version of TM5 is now able to:
  - Read meteo fields from disk ...
  - ... or from memory arrays (PRISM interface)
  - Interpolate from spectral/gg to lat/lon
- Meteo input is 'embarrassingly' parallel: each processor a different field ...

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With the essentials of TMPP fitted inside TM5, it would have been possible to use the following configuration:

**ECHAM** ⇔ **OASIS3** ⇔ **TM5**

But with the toy-models already running we decided to compile TM5 into a library, which is called from a small separate program, “chem” (adapted from the PRISM toychem model), that would handle all field exchanges with IFS.

Further TM5-development can then take place completely separated and independent from GEMS-issues:

**ECHAM** ⇔ **OASIS3** ⇔ **chem**  
↕  
**{TM5-library}**





## Introduction to ECHAM

ECHAM is a general circulation model (GCM), or climate model. Contrary to TM the meteorological processes are explicitly solved in this model. ECHAM was developed from the ECMWF weather forecast model at the Max Planck Institute for Meteorology in Hamburg.

(We took the ECHAM-version from the coupled Atmosphere-Ocean system “ECHO”, with all prism-routines already available in module MO-COUPLE; all “A2O”-routines modified to “A2C”-routines, etc.)



•••• A quick Comparison of ECMWF output to  ECHAM output

	<b>ECMWF</b>	<b>ECHAM</b>
Format	GRIB	NetCDF
# Vertical Levels	(16, 19, 31, 40, 50) <b>60</b>	19, 31, 39, 90
Horizontal Res.	TM uses: <b>T159</b>	T19, T42, T63, T106
3-D fields (spherical harm.)	Divergence Vorticity Temperature Vertical velocity	Divergence, Vorticity, Temperature
3-D fields (Gaussian grid)	Specific humidity Cloud liquid water Cloud ice Cloud cover	Specific humidity Cloud liquid water Cloud ice Cloud cover
•••• Many 2-D fields	e.g. orography etc.	Idem...



## Adaptation of ECHAM to the TM5 coupling

- mo\_couple.f90 : module containing all subroutines dealing with the oasis-coupling
- radiation.f90 : assign the TM5 ozone field
- mo\_knmi\_chem.f90: new module, mainly output
- New routine to split 3-d fields in 2-d fields
  
- Standard PRISM resolutions in ECHAM are T21L19, T63L31 and T106L31 (all low, non-middle atmosphere versions). For these resolutions standard PRISM initial fields exist.
- However, we wanted to run an MA-version (top: 0.01 hPa ~ 85 km). Minimal horizontal resolution is T31.
- We got T31L39 initial files from Hamburg. Names are adapted to prism-standards.
- Land sea mask is not yet adapted, so ocean cannot be coupled



# • Specifications of the coupled TM5-ECHAM



- ECHAM version T31L39 (MA-version)
- In ECHAM meteo 3d-fields are split in 2d-fields
- In TM5 gridded ozone is split in 2-d fields.
- Models run sequentially in “shifted” timeframes:
  - [1] ECHAM starts running from  $t = 0 - 6$  h
  - [2] At “ECHAM-time” = 6 h, vorticity, divergence, temperature and ground pressure are sent to  $t = 3$  h in TM
  - [3] TM runs from 3 – 9 h
  - [4] At “TM-time” = 9 h, ozone is sent to  $t = 6$  h in ECHAM
  - [5] Echam runs form  $t = 6 - 12$  h
  - Etc.
- Not completely stable yet, not fully tested, too slow



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## At present: involved with GEMS and OASIS4

- In GEMS, TM5 is being coupled to IFS.
- A lot of work is being done by ECMWF
- We have chosen the same approach as in PRISM: the preprocessor TMPP is integrated into TM5, and TM5 will be called as a library.
- A lot more fields will be coupled. (O<sub>3</sub>, NO<sub>x</sub>, CO, CH<sub>4</sub>, CH<sub>2</sub>O, SO<sub>2</sub>)
- For reasons of consistency and stability, production and loss terms will be transferred (ongoing discussion)
- OASIS4 may solve a lot of our problems: 3d-fields, easier interface, faster, etc.

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## The future and distant future.

- PRISM: We have a working coupled system (ECHAM- TM5). Proposals have been submitted for experiments with this system.
- GEMS: is expected to keep us busy for a few more years.
- KNMI is planning to put more effort into Earth Modeling from 2006 onward.

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