Tracer transport and mixing processes investigated with the MECO(n) system

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Outline

1. The MECO(n) system
2. Stratosphere-to-troposphere transport (STT) analysed using MECO(n)

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   - infrastructure MESSy
   - setup

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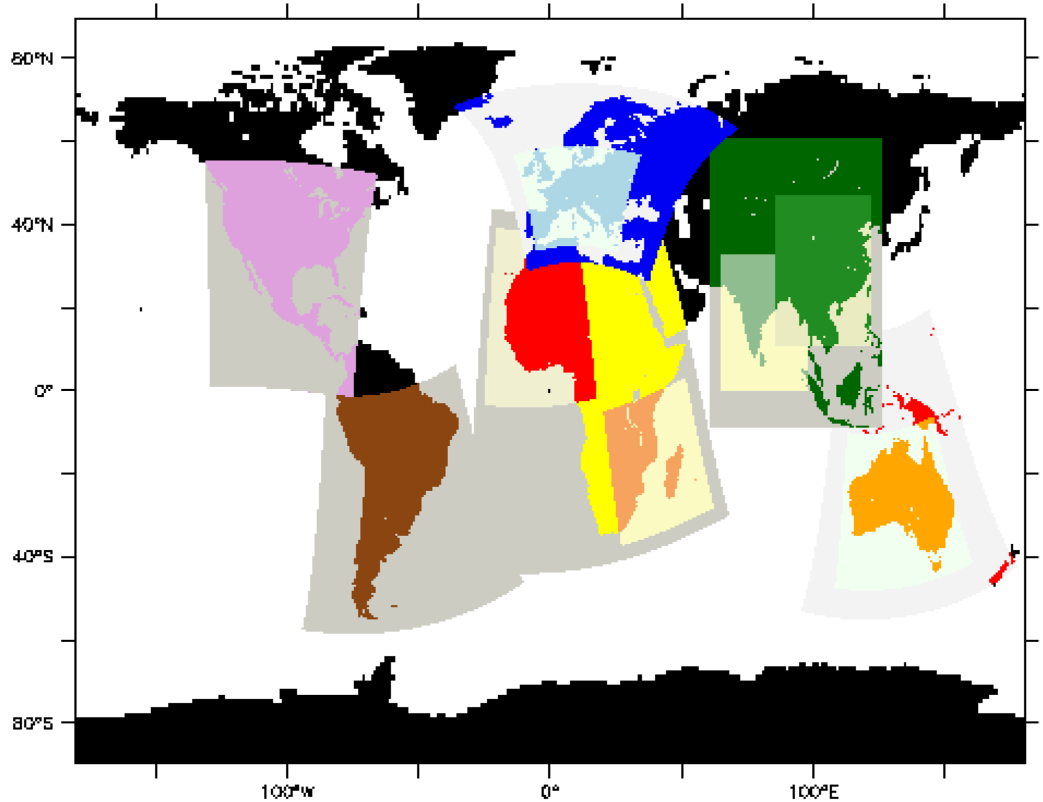
MECO(n) =

"MESSy-fied ECHAM and COSMO models nested n-times"



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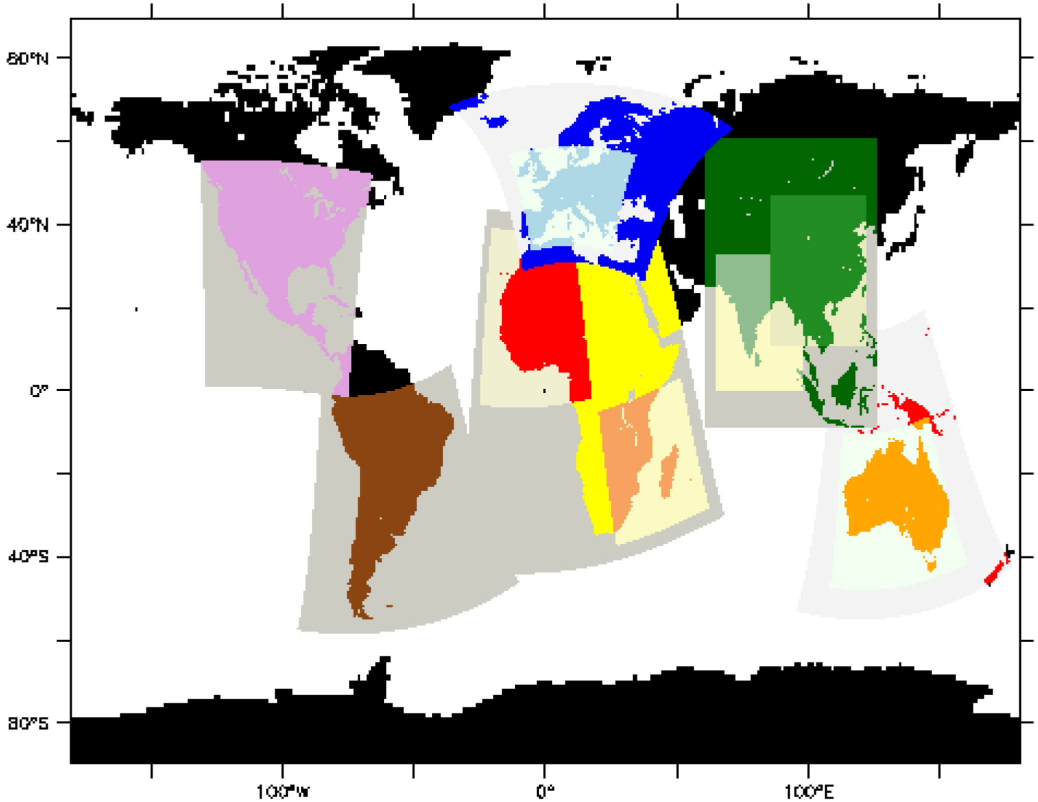
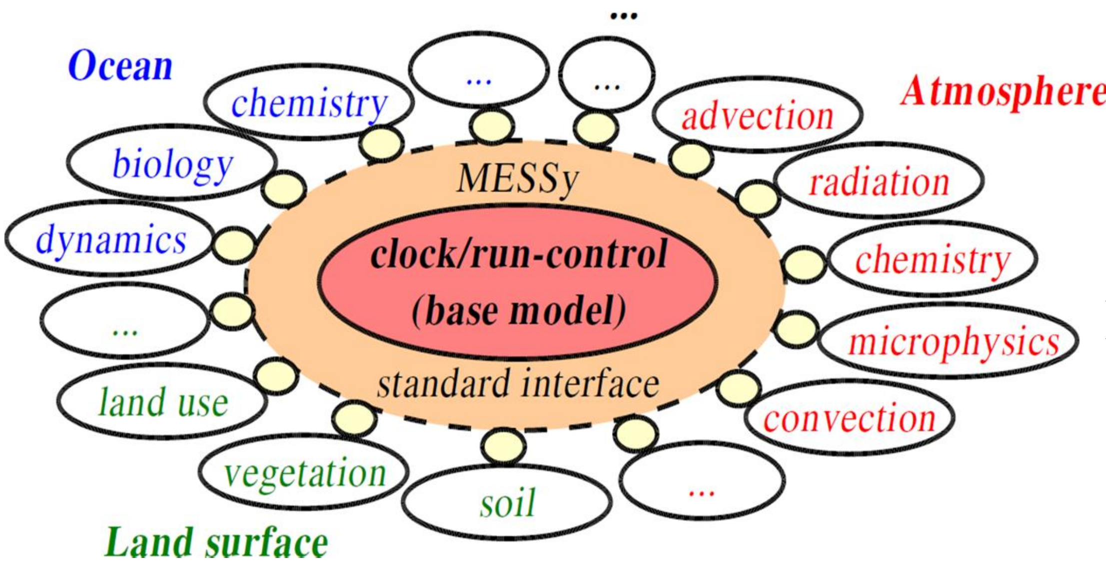


The MECO(n) system

MESSy: Modular Earth Submodel System



- Idea: Each process is coded as a modular entity (submodel) and connected via MESSy to a basemodel

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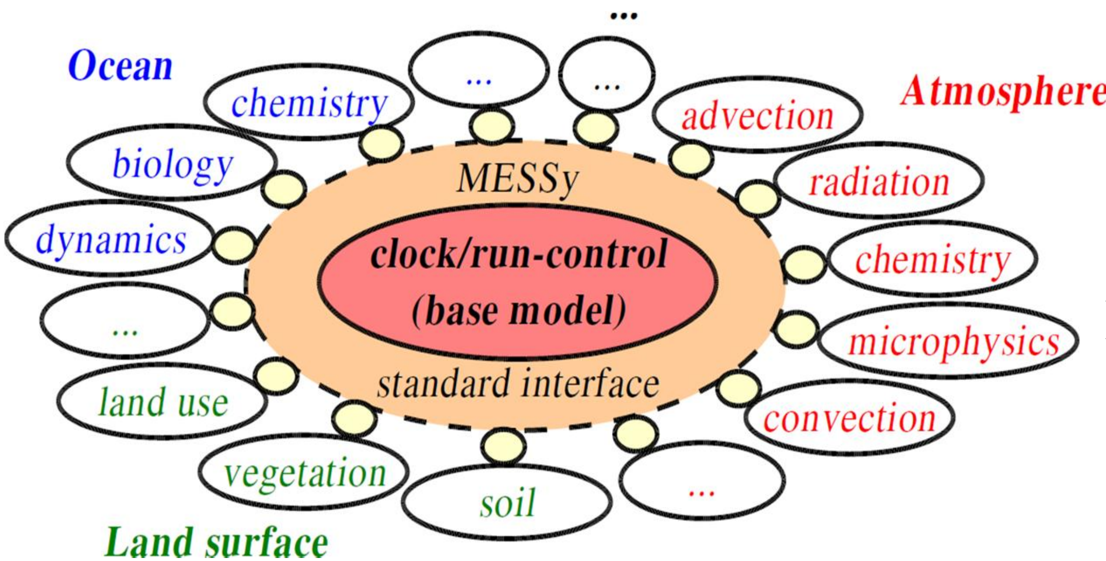
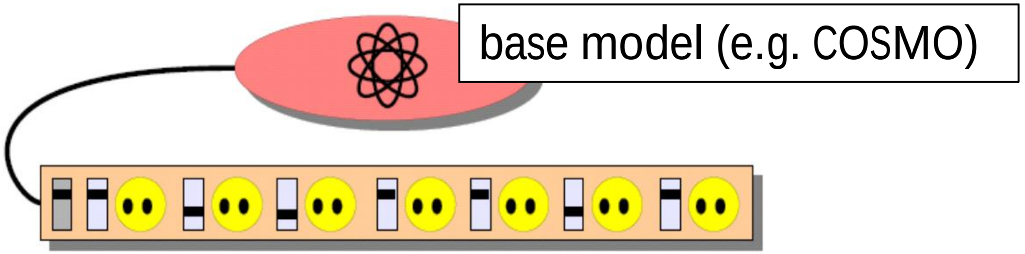


- Idea: Each process is coded as a modular entity (submodel) and connected via MESSy to a basemodel

base model → ECHAM → ECHAM/MESSy → EMAC

base model → COSMO → COSMO/MESSy

The MECO(n) system



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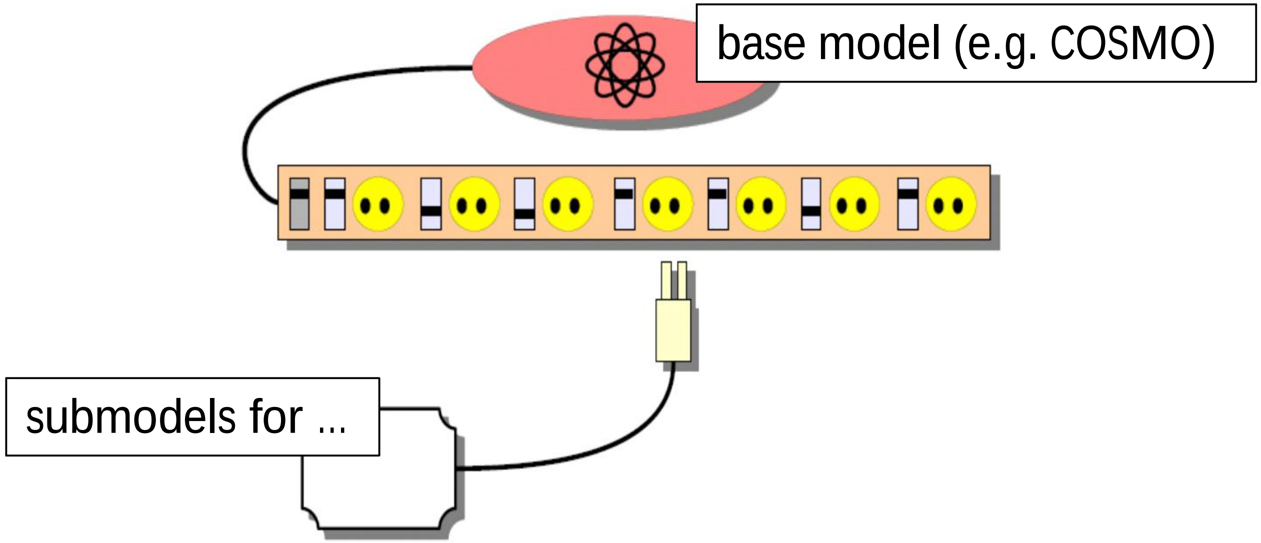

... processes

- MECCA
- SCAV
- SEDI
- DDEP
- ...

... infrastructure

- CHANNEL
- TIMER
- TRACER
- ...

... utilities

- TROPOP
- SCOUT
- PTRACINI
- ...

The MECO(n) system

Technically, MESSy comprises:

- standard interfaces to couple the different components
- a simple coding standard
- a set of submodels

MESSy, implemented in COSMO5.0:

- pre-processor directives
- MESSy code available on request (http://www.messy-interface.org/)

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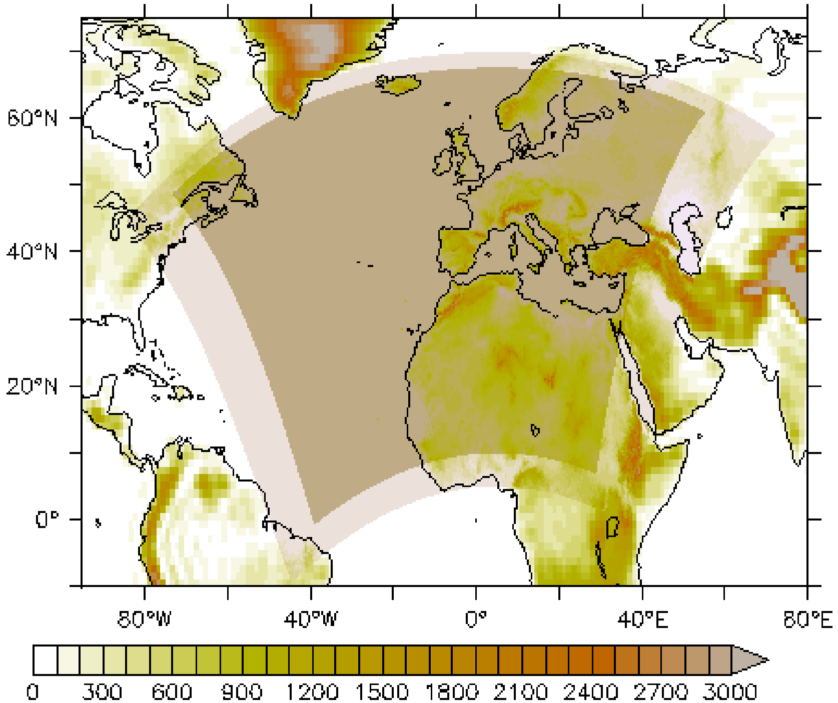
The MECO(n) system

- MECO(2) setup → two COSMO/MESSy instances nested in the global EMAC instance

spatial setup:



height of topography in m

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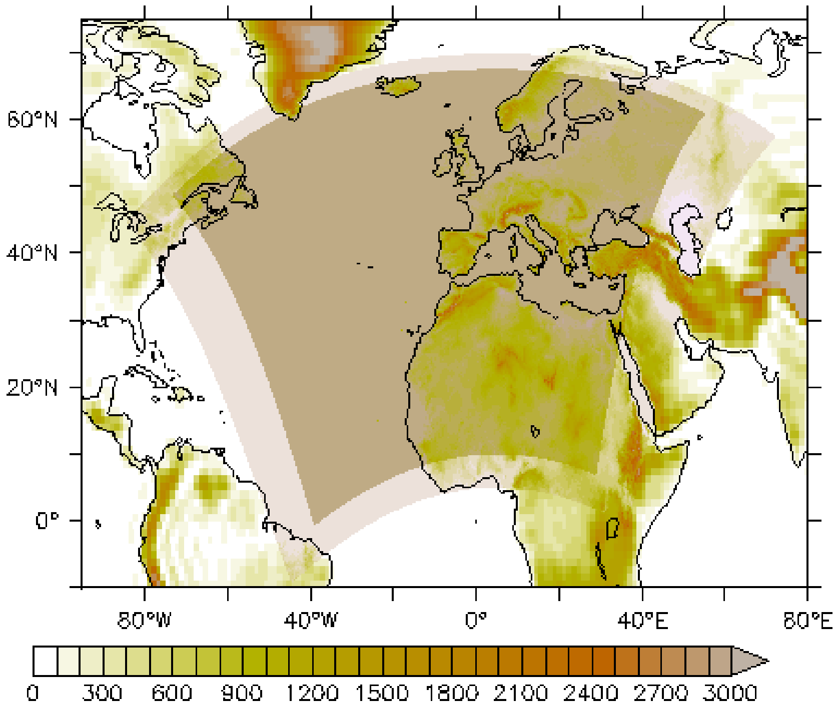

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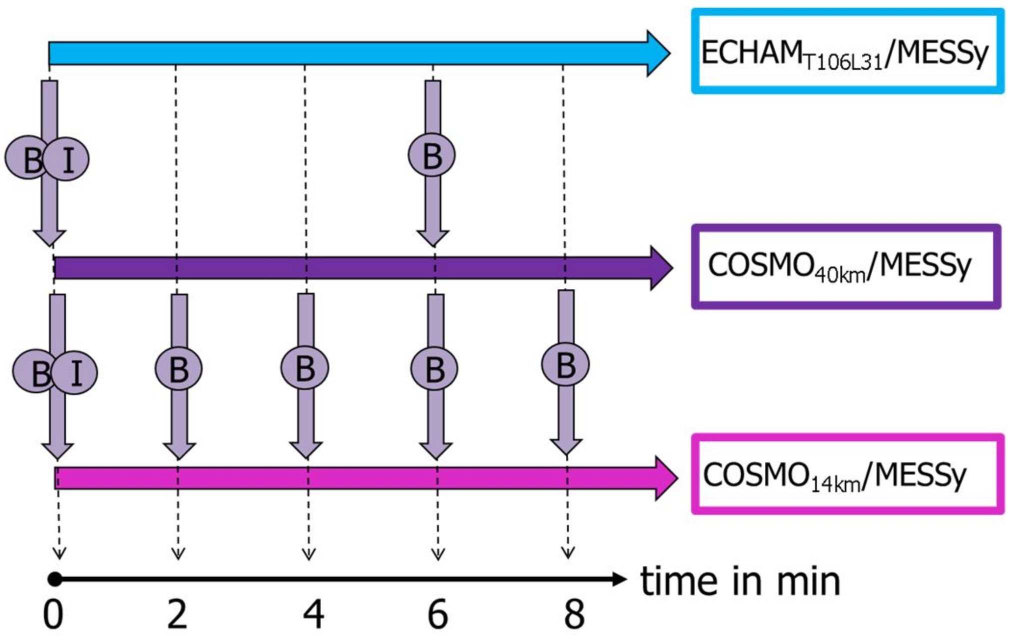
temporal setup:



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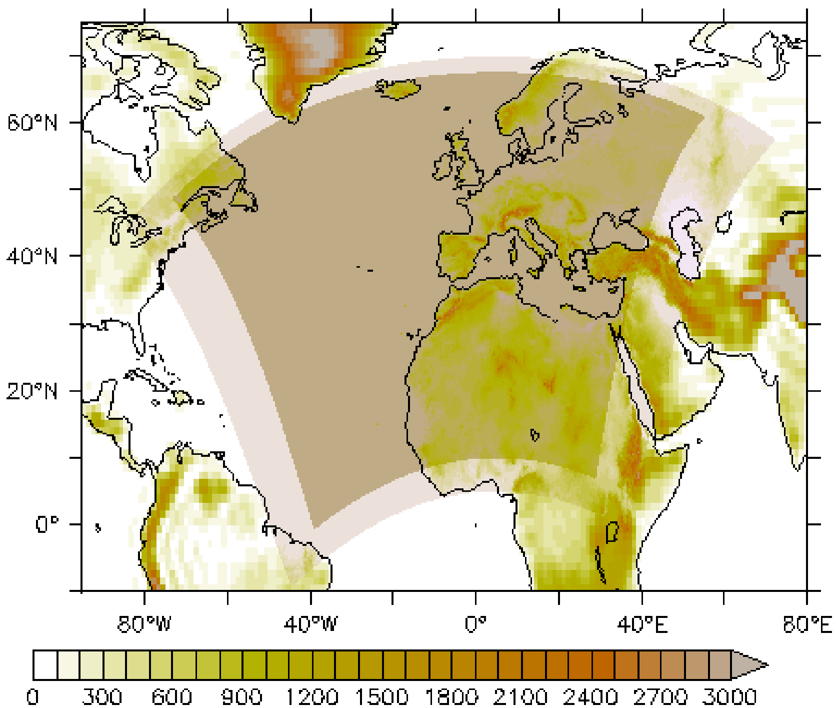

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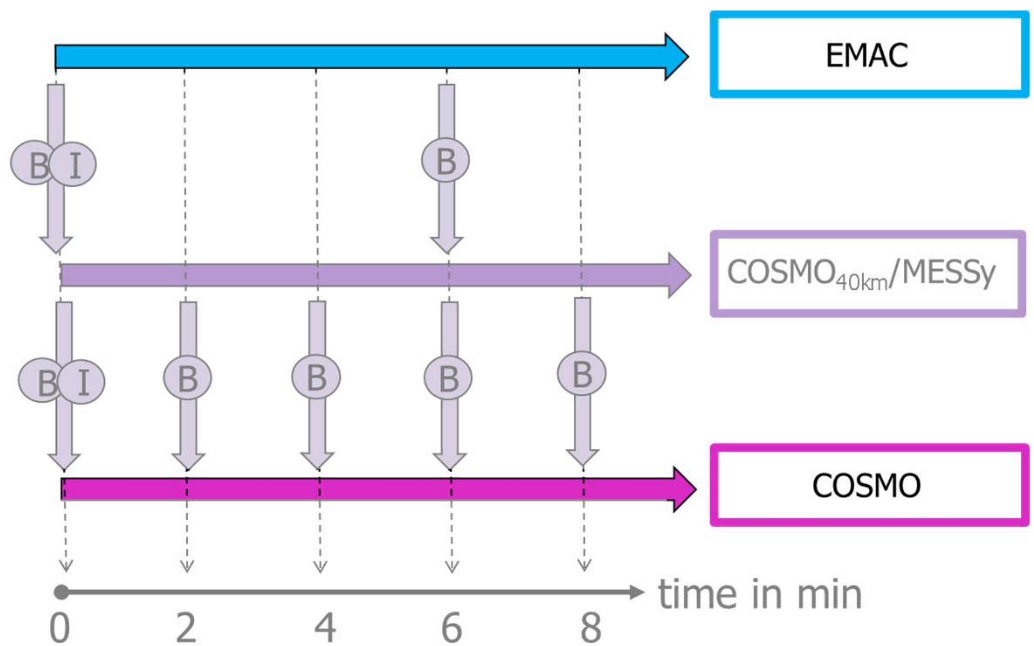

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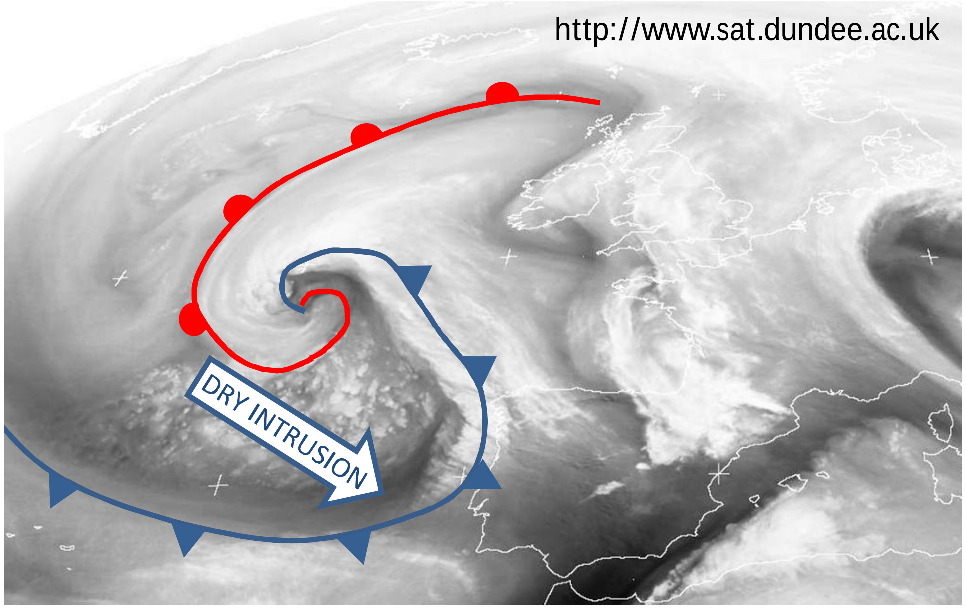
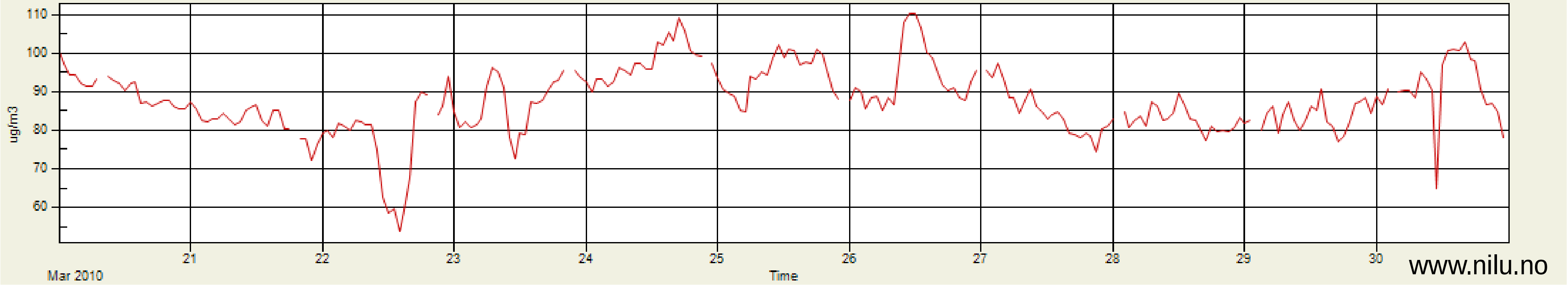
- case study of a low pressure system ''Judy'' in March 2010
- satellite image on 25th March 00UTC:



- time series of O_3 in µg/m³ measured at Schauinsland in March 2010



STT in MECO(n)

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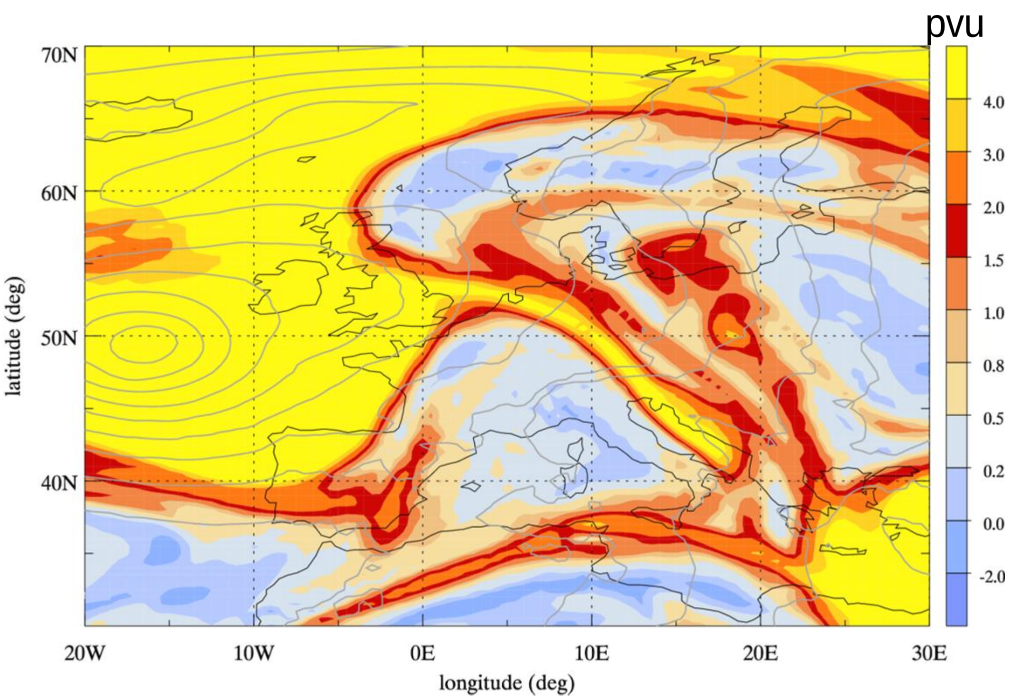
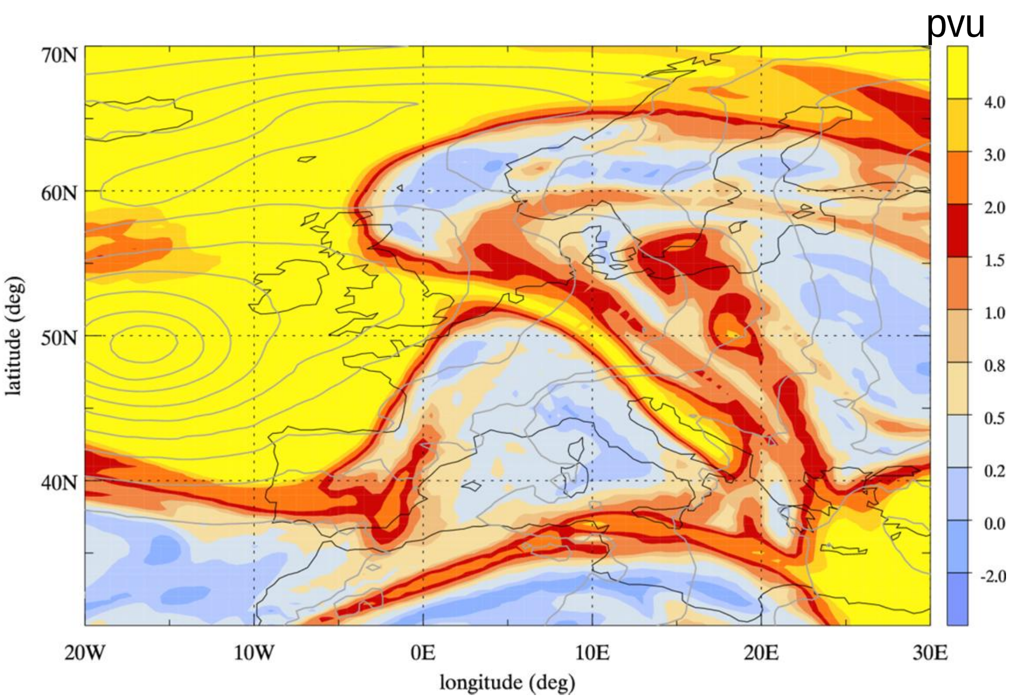
- ECMWF analysis show a strong through above the low-pressure system

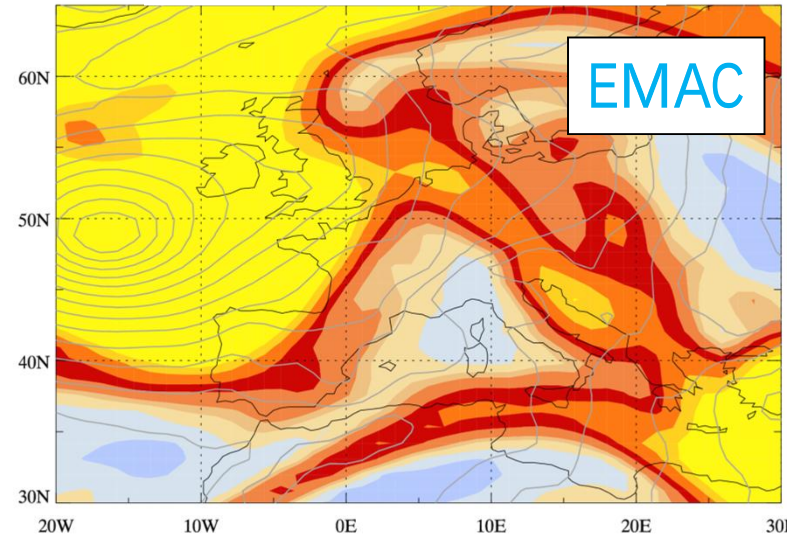


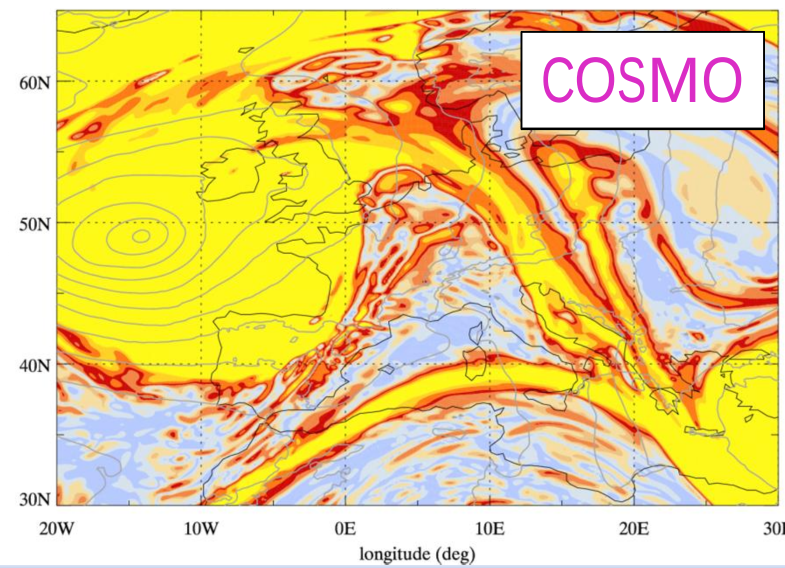
PV at 250 hPa, sea level pressure in contours

STT in MECO(n)

- comparison of analysis and model data:
  MECO(n) is able to capture the low-pressure system



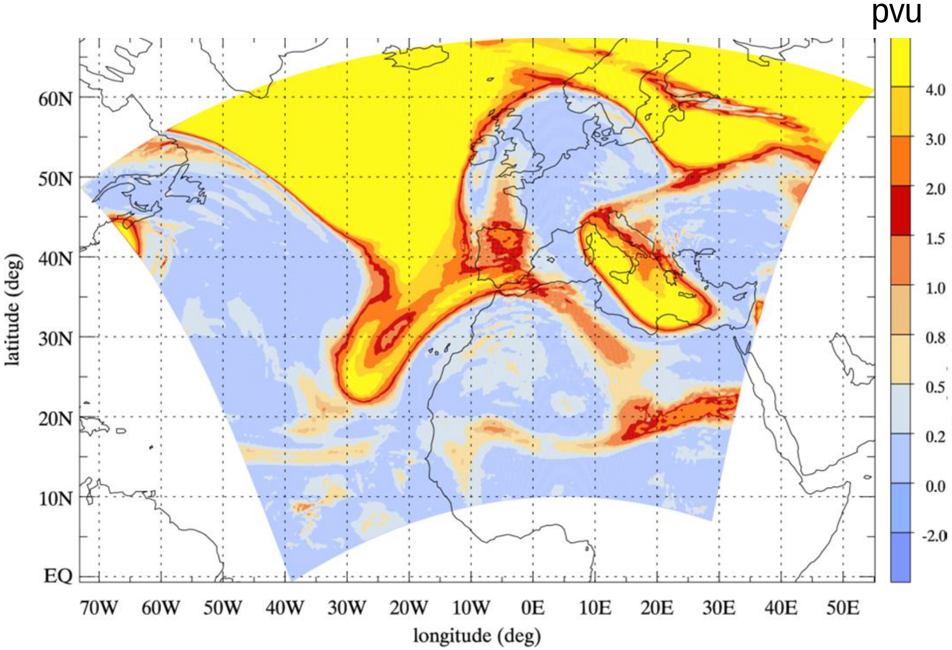


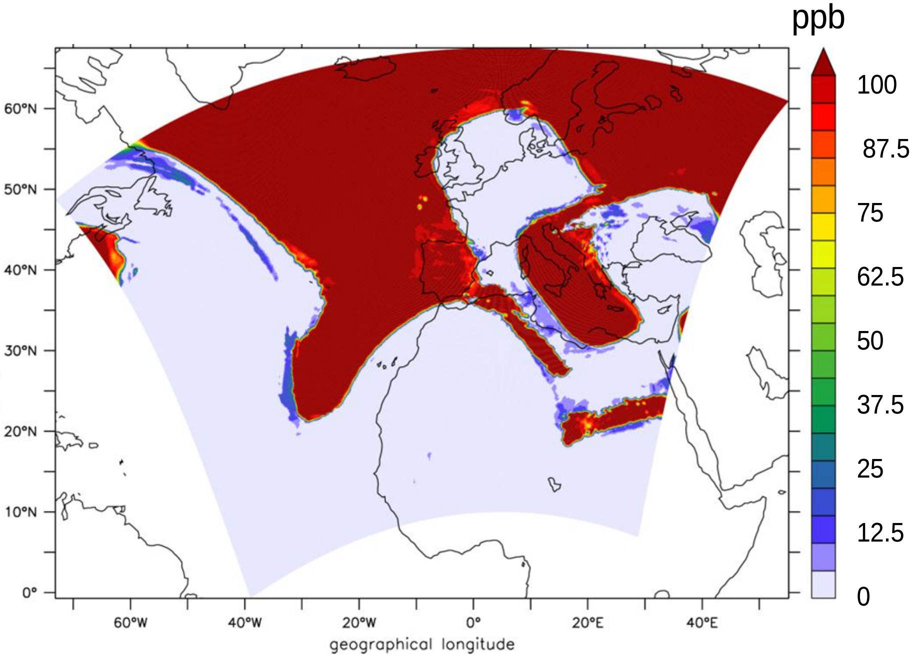


PV at 250 hPa, sea level pressure in contours

STT in MECO(n)

- simulation period: 24th March to 28th March 2010
- artificial passive tracer initialised (STRATO)
- PV and mixing ratio of STRATO at approx. 250 hPa one hour after initialisation:





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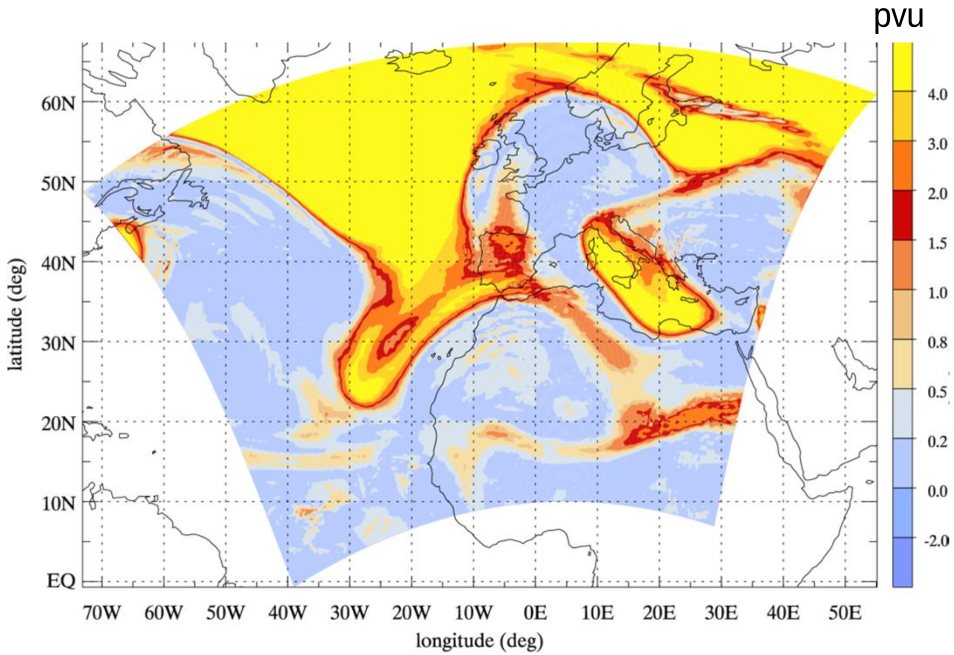

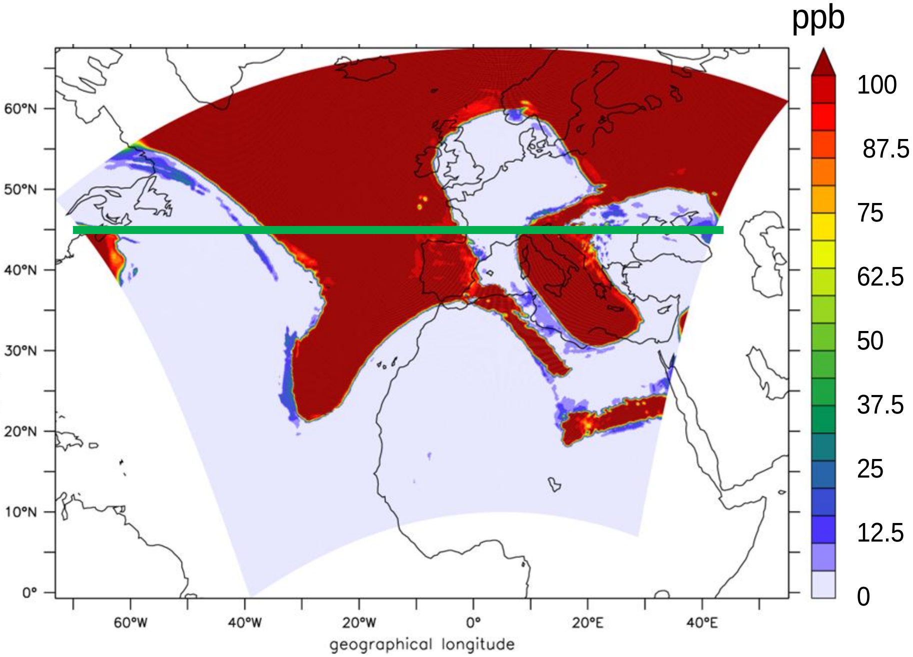

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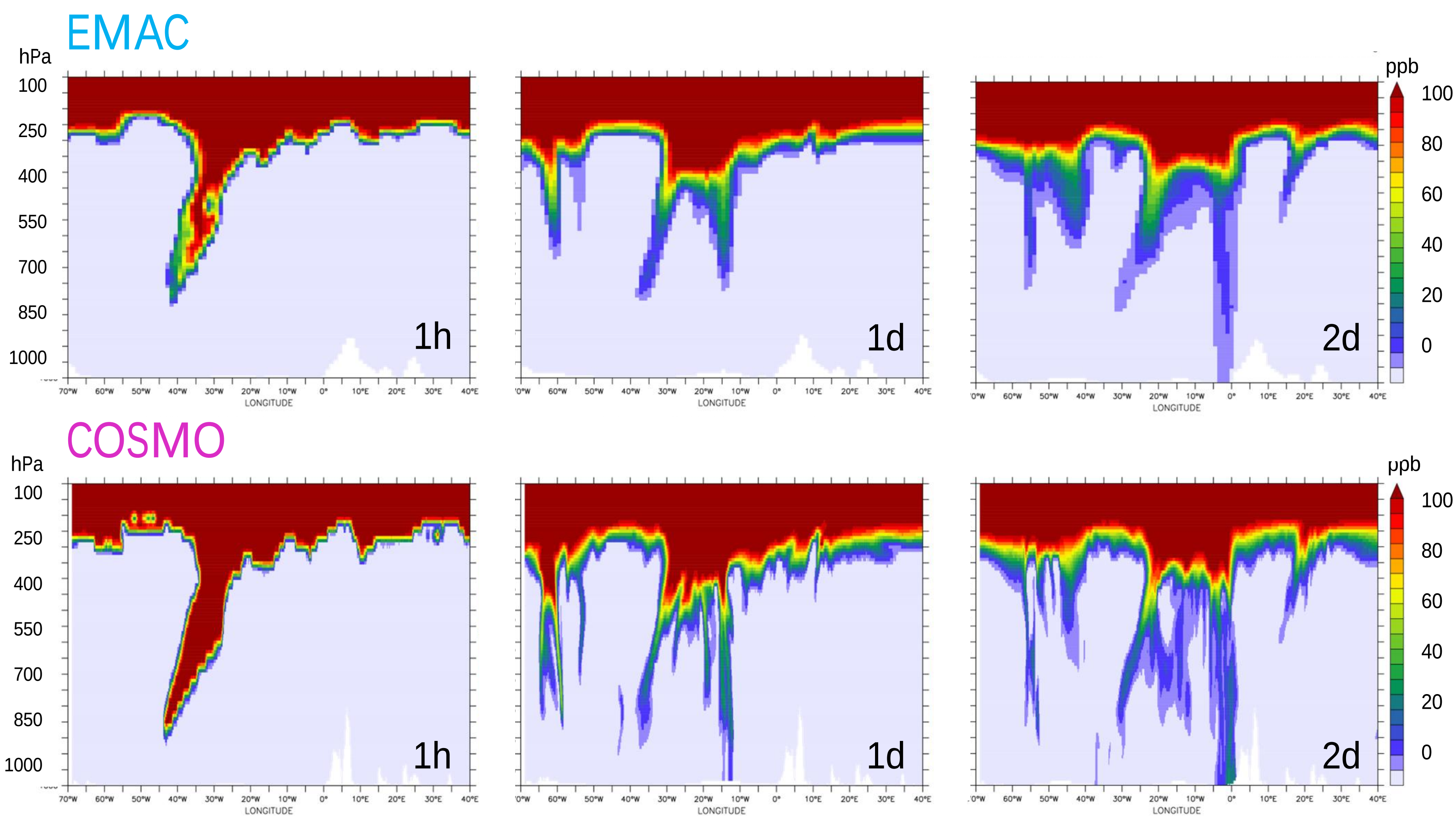
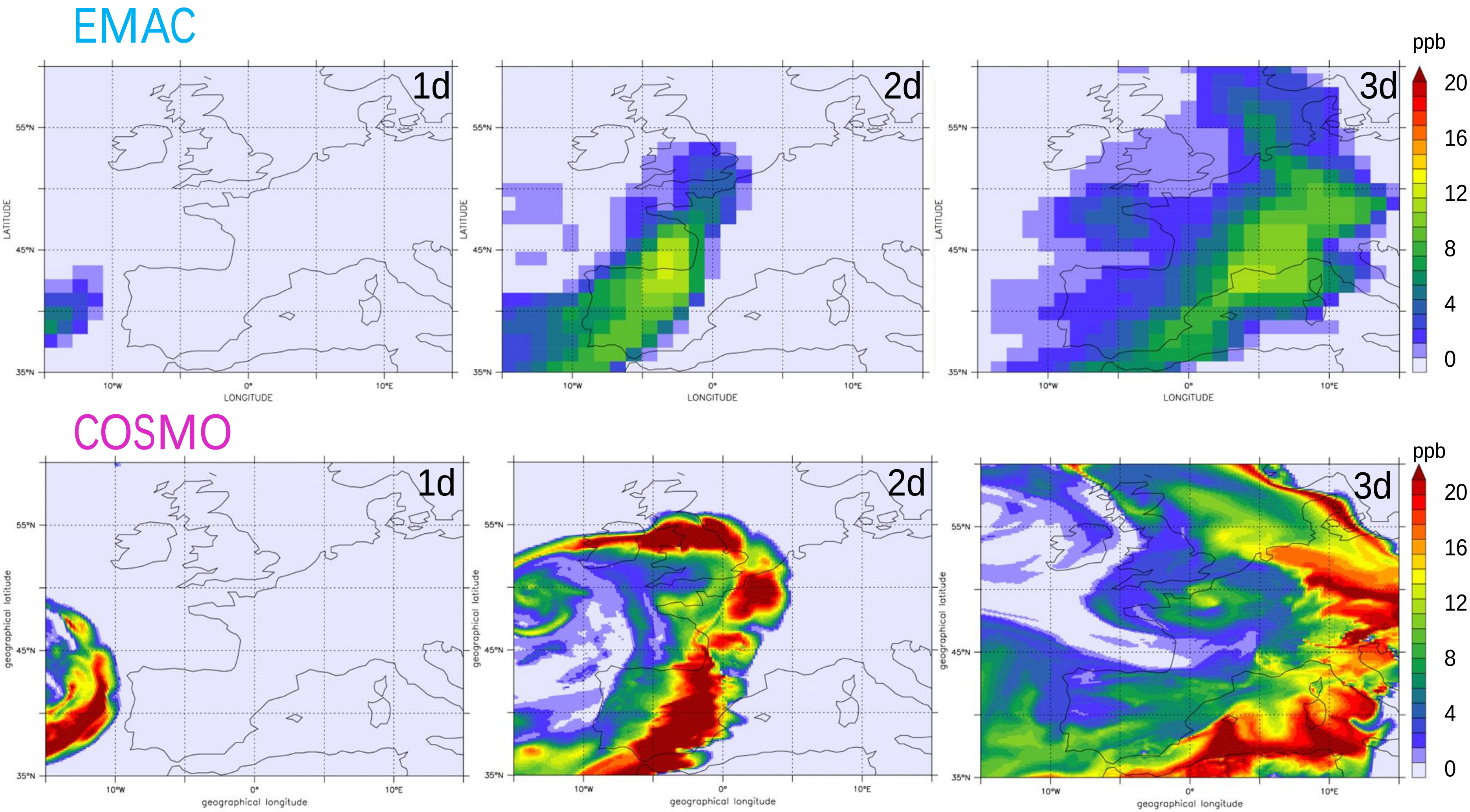


- vertical cross sections of stratospheric tracer distributions along 45° N
- tracers are transported downward along the tropopause fold

STT in MECO(n)



- horizontal distribution of stratospheric tracers at lowest model level
- tracers descend behind the cold front (dry-airstream)

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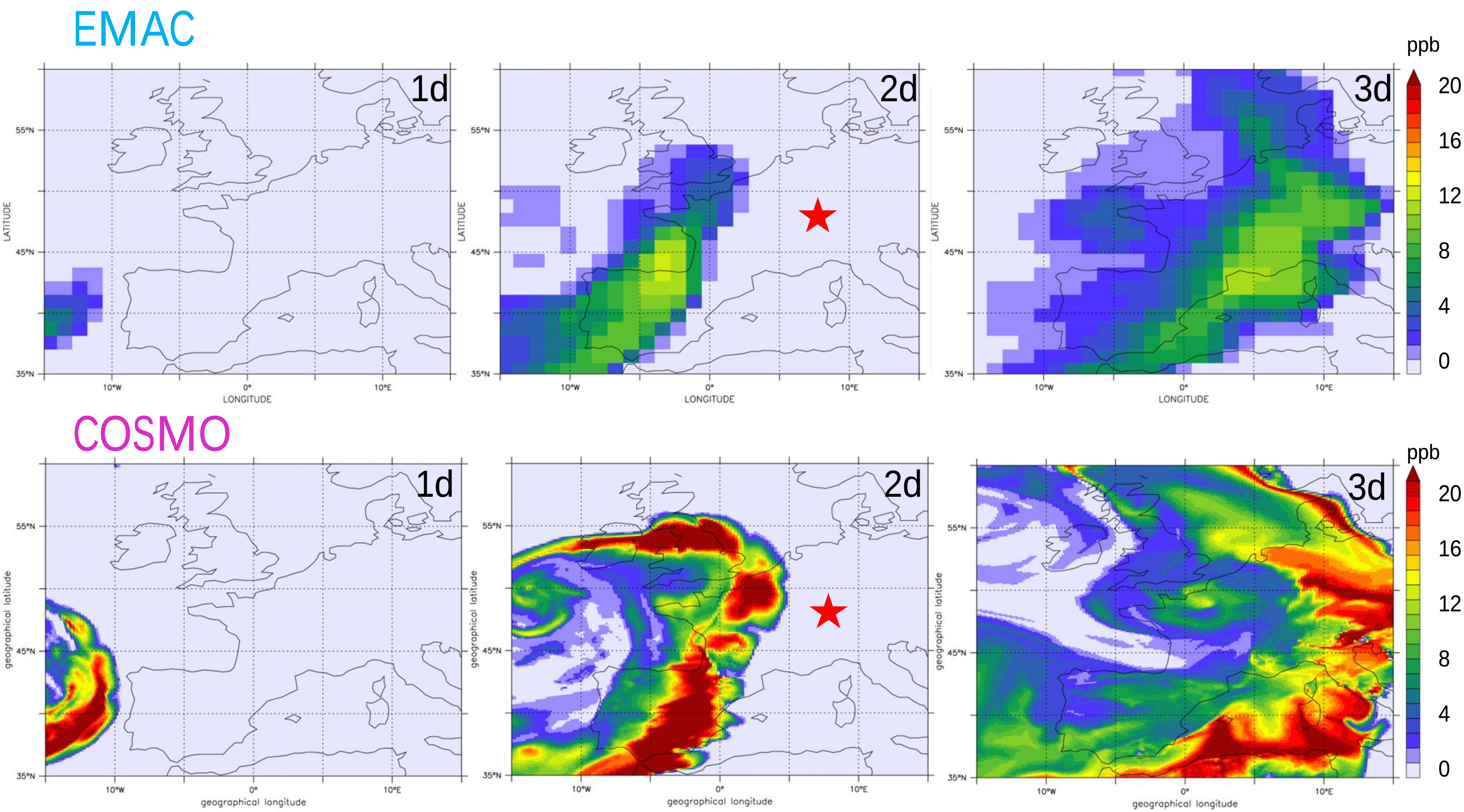

- horizontal distribution of stratospheric tracers at lowest model level
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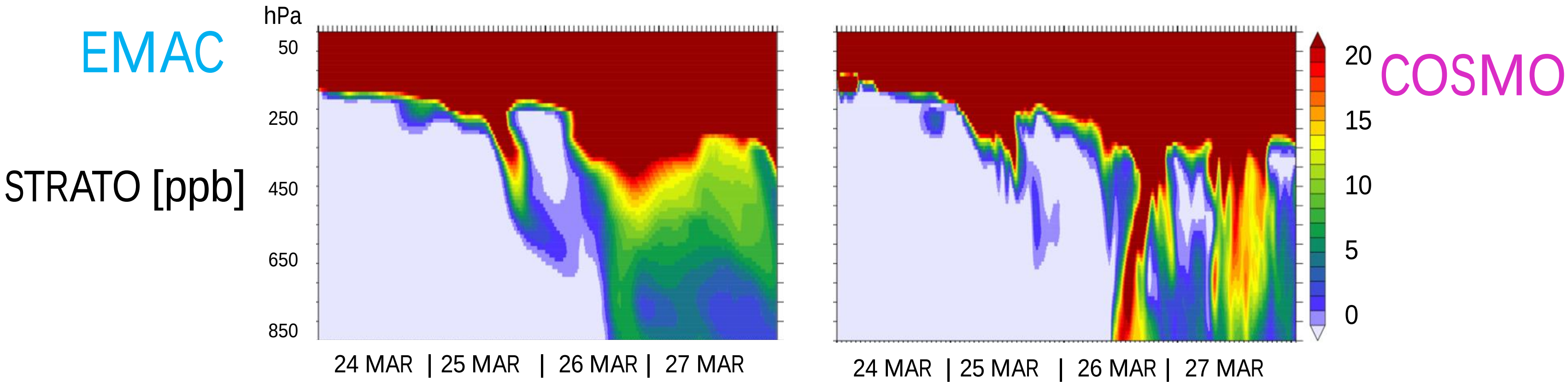
★ position of Schauinsland (47,9°N / 7,9°E / 1205m)

STT in MECO(n)

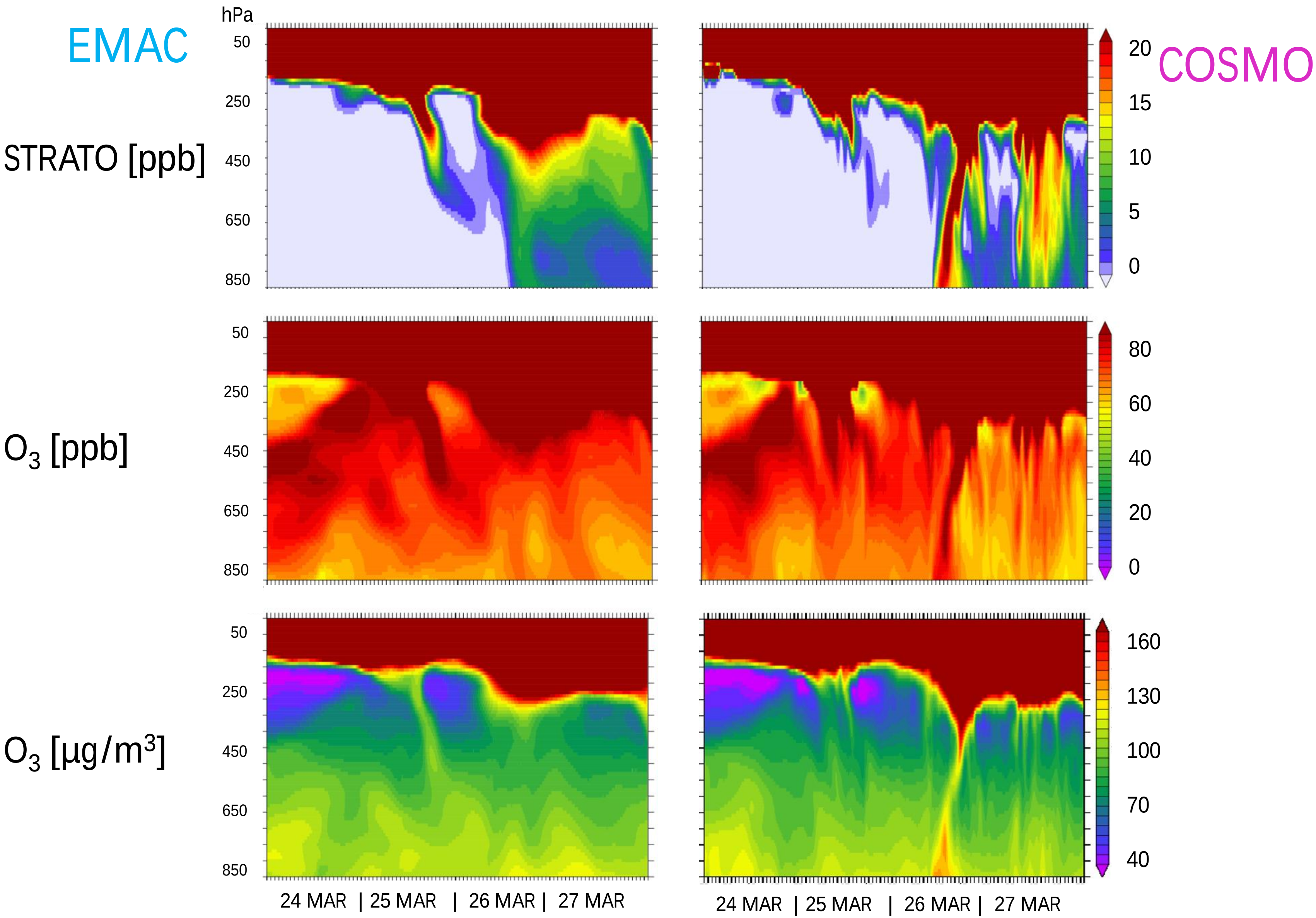


- time series of vertical columns of stratospheric tracers at Schauinsland between 24th March (day of initialisation) and 27th March (3rd day after initialisation)

- strong increase of stratospheric tracer mixing ratio for COSMO on 26th March 12UTC

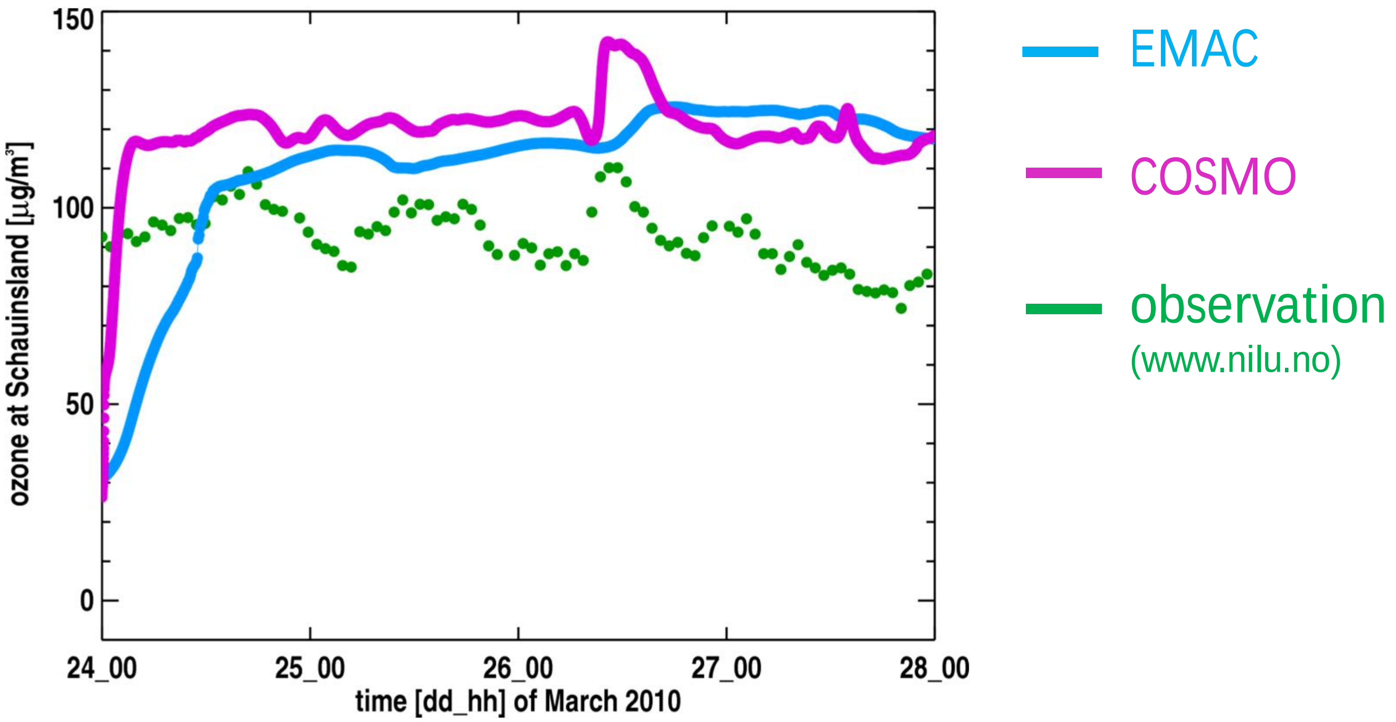
- ➢ couple ozone data (passively) to compare differences with observations

STT in MECO(n)



EMAC
COSMO
STRATO [ppb]
O_3 [ppb]
O_3 [µg/m^3]
hPa
50
250
450
650
850
20
15
10
5
0
80
60
40
20
0
160
130
100
70
40
24 MAR | 25 MAR | 26 MAR | 27 MAR
24 MAR | 25 MAR | 26 MAR | 27 MAR

STT in MECO(n)



- temporal development of ozone simulated by COSMO at lowest model level coincides with observational data
- passive ozone of EMAC doesn't show the sudden increase
- difference between the masses of passive treated ozone and observation are the consequence of missing degradation processes

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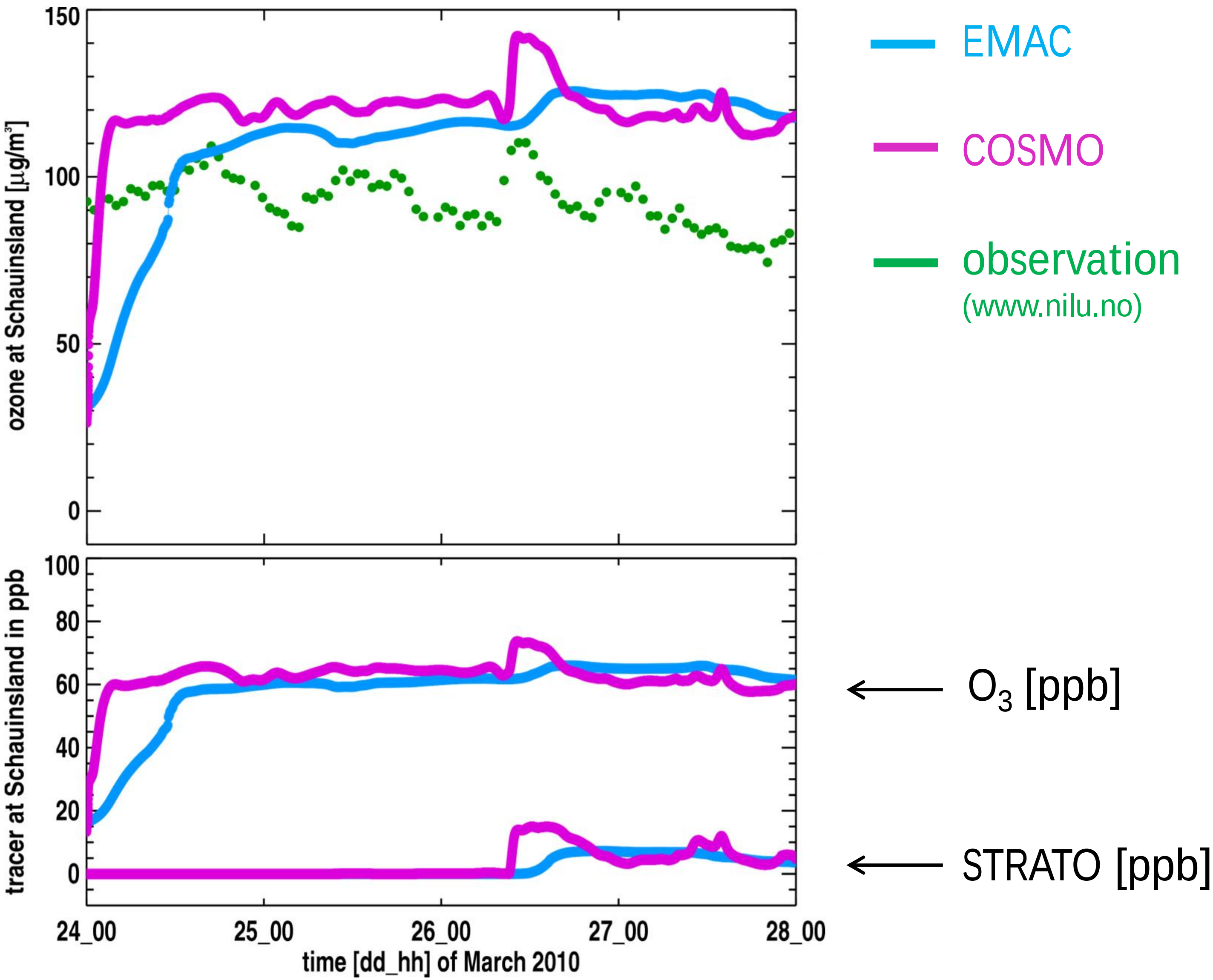
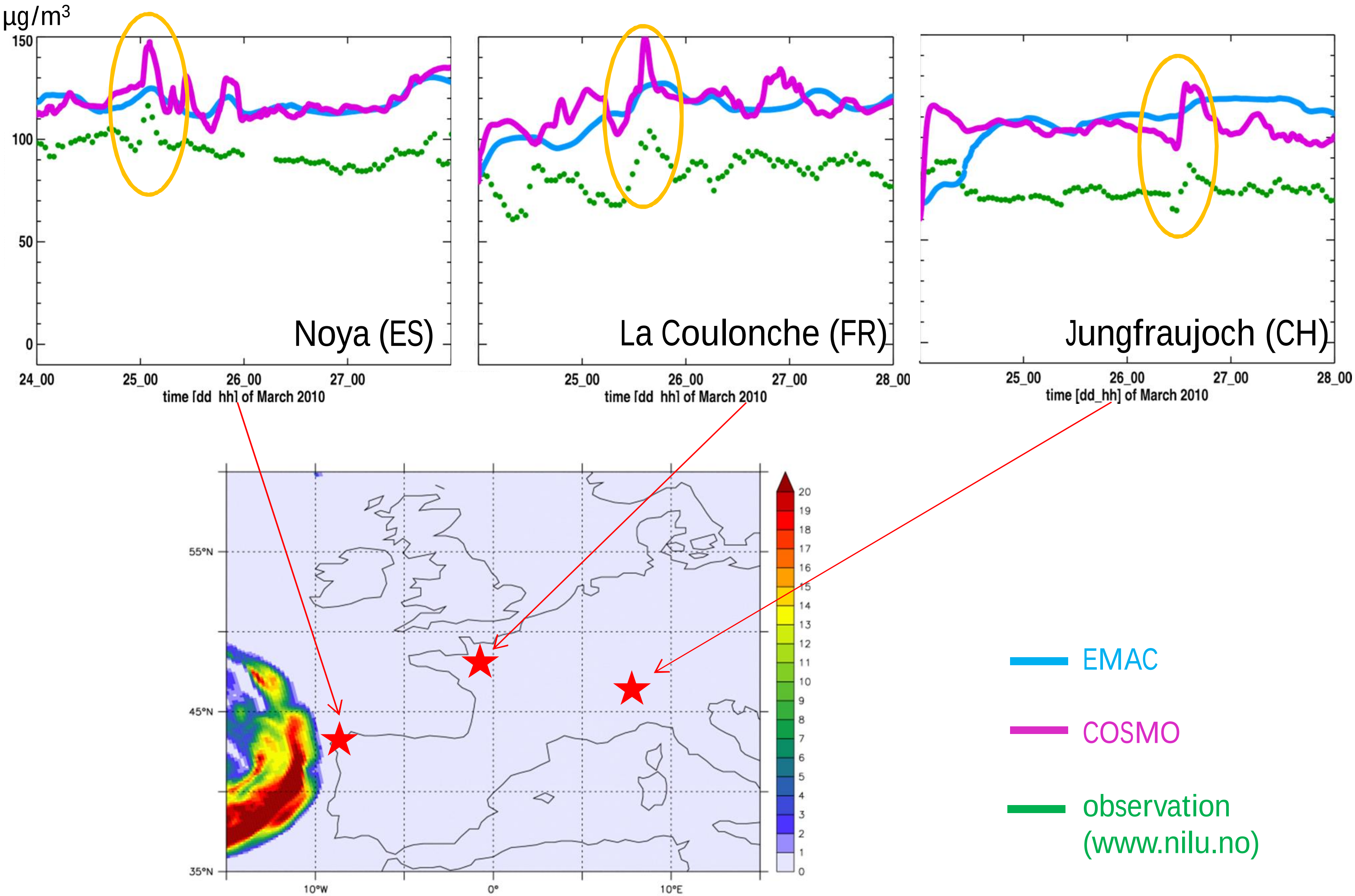


150
100
50
0
ozone at Schauinsland [µg/m³]
100
80
60
40
20
0
tracer at Schauinsland in ppb
24_00
25_00
26_00
27_00
28_00
time [dd_hh] of March 2010
EMAC
COSMO
observation
(www.nilu.no)
O3 [ppb]
STRATO [ppb]

STT in MECO(n)


µg/m³
150
100
50
0
Noya (ES)
24_00
25_00
26_00
27_00
time [dd hh] of March 2010
La Coulonche (FR)
25_00
26_00
27_00
28_00
time [dd hh] of March 2010
Jungfraujoch (CH)
25_00
26_00
27_00
28_00
time [dd_hh] of March 2010
55°N
45°N
35°N
10°W
0°
10°E
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
EMAC
COSMO
observation
(www.nilu.no)

Summary

We used the MECO(n) system to analyse a case study where stratospheric air masses are transported to lower tropospheric levels:

- the temporal development of passive ozone, simulated with the COSMO/MESSy instance, fits the measurements much better compared to the EMAC instance
- initialised artificial stratospheric tracers enable the determination of transport of stratospheric ozone into the troposphere

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Thank you for your attention !!!