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CONSORTIUM FOR SMALL SCALE MODELING

COSMO

NWP in aviation:

CAT diagnostics

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Topics

- Motivation and backgroud
- Use of NWP in aviation (non exhaustive)
- CAT diagnostics from COSMO-7
- Outlook

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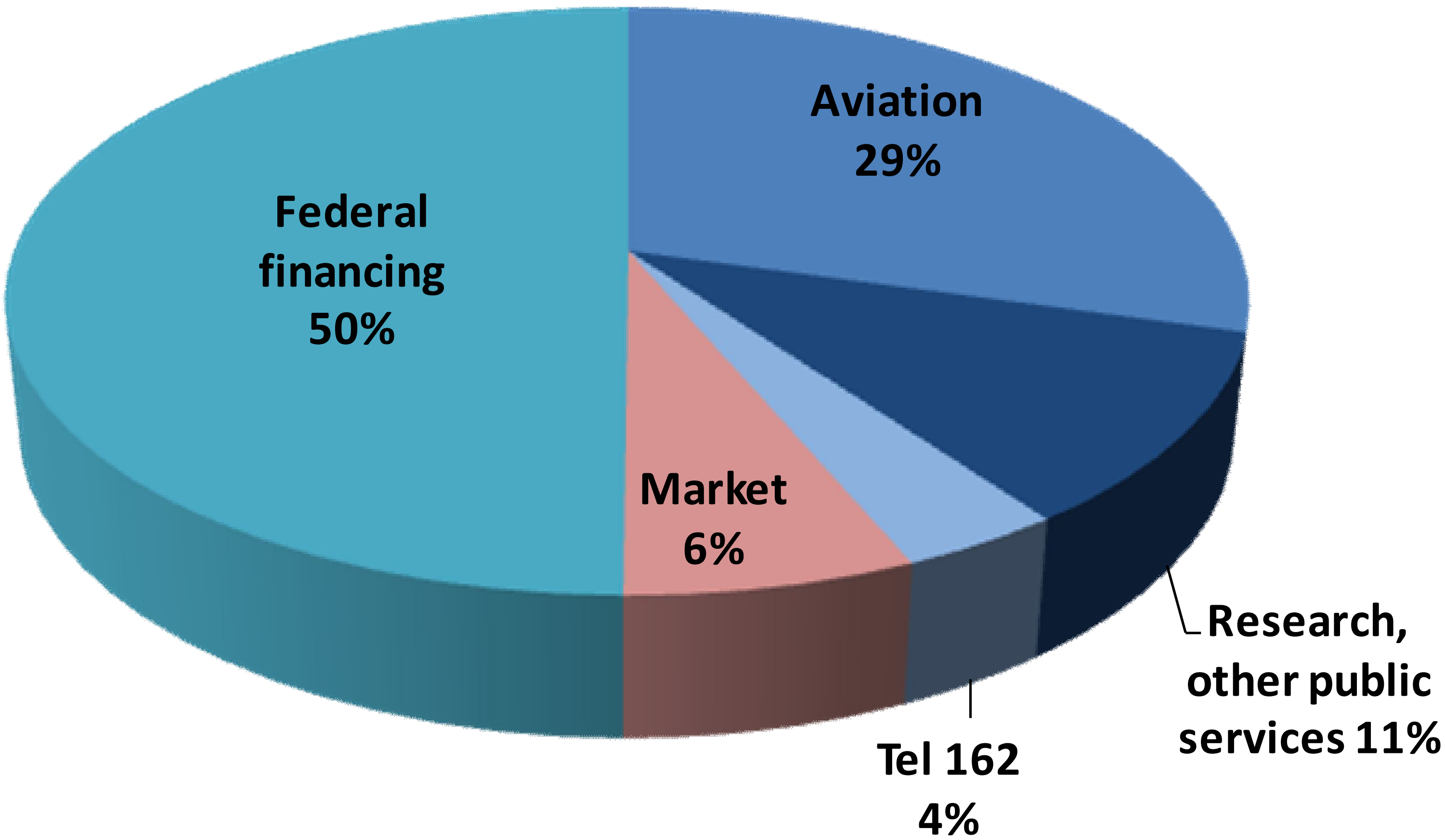
Income (MeteoSwiss)



The Schwarzwälder Torte or Zuger-Kirschtorte

Expectations from aviation (managers)

- Lower costs from weather providers (direct, core)
- More expectations for optimising the operations
  - Wind forecasts
  - Parameters usually not included in models: icing, CAT, fog, lightning…
- *The weather is still an important factor for air traffic despite all technical advances*
- Tendency to fusions airspaces: ATC → ¿Met?
- Met services have to tackle these challenges in close collaboration

NWP in aviation

- Global models are used since some time
- Regional models can help catching local/small scale phenomena
- Postprocessing is still necessary
  - Local adaptation
  - Parameters not directly present in the model

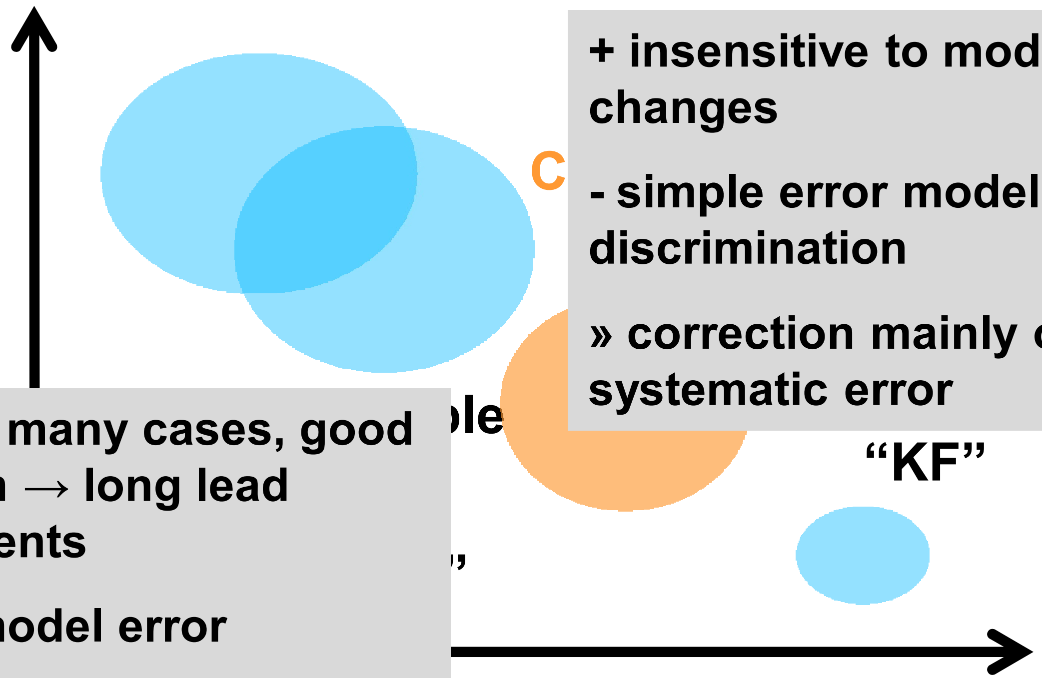
MOS on local NWP models

CONSORTIUM FOR SMALL SCALE MODELING COSMO

global MOS

Length of training period ~

MOS complexity



+ insensitive to model error changes

- simple error model, little discrimination

» correction mainly of the systematic error

+ sampling of many cases, good discrimination → long lead times, rare events

- inert when model error changes

» reduction of the mean error and its variability

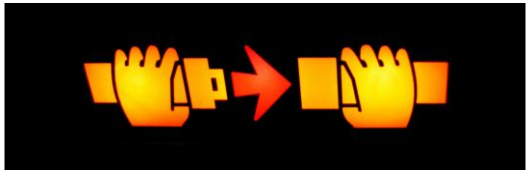
COSMO MOS

- Done: wind speed and gusts
- Optimal training period: ~90 days

- Planed: wind direction, ceiling, visibility

Let's move to CAT

- Clear Air Turbulence
- Outside wet convection
- Not directly visible (eye, radar)



- Can injure crew and passengers and even affect flight safety
- Can affect vertical separation of aircrafts: RVSM of 1000ft has to be relaxed

- Atmospheric situations causing CAT not fully understood (jet stream, breaking gravity waves...)

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

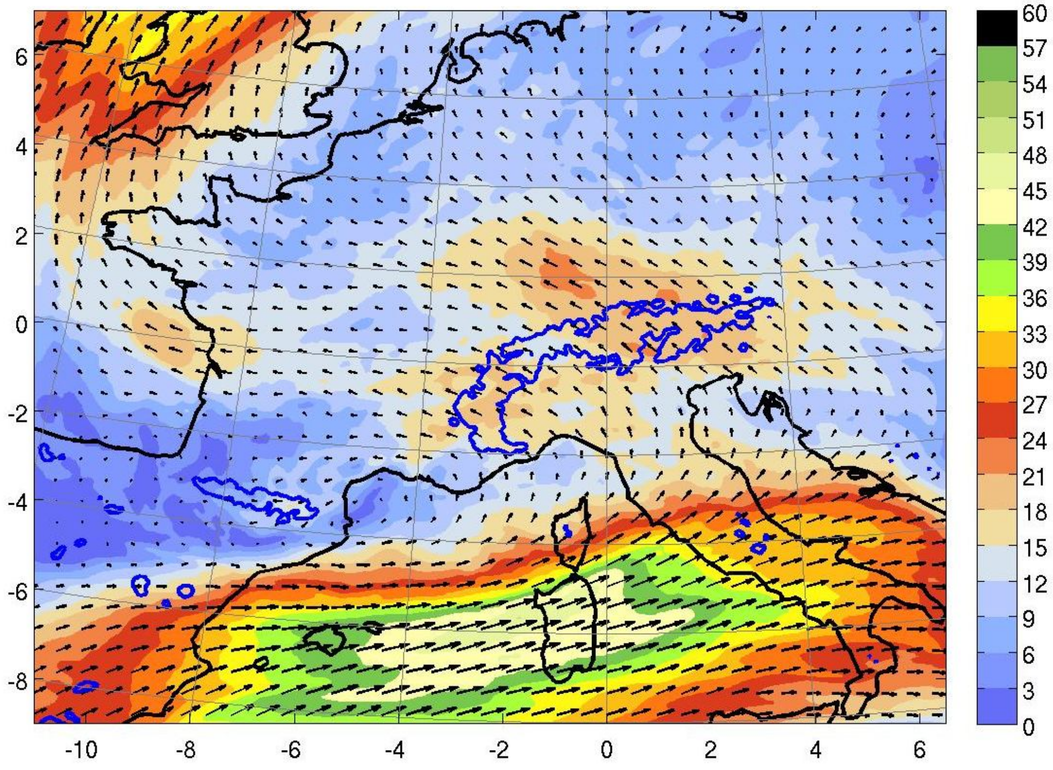
IACETH

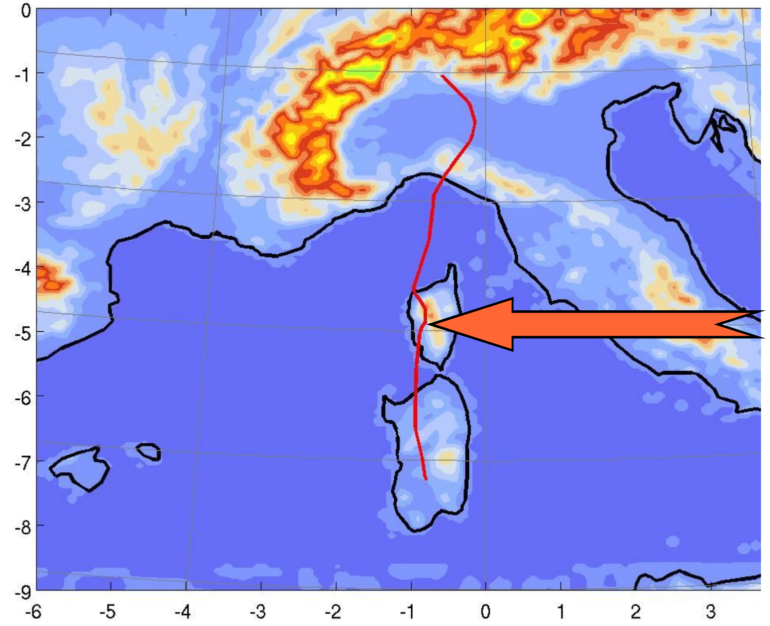
Clear Air Turbulence over Europe: Climatology, Dynamics and Representation in COSMO-7

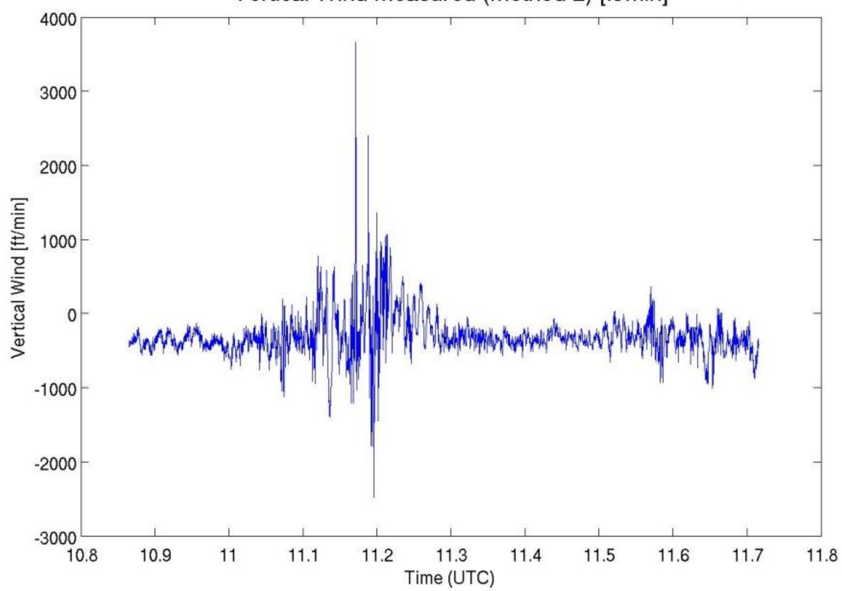
Masterthesis of Lysiane Mayoraz
Supervised by Michael Sprenger and Vanessa Stauch

Case Study

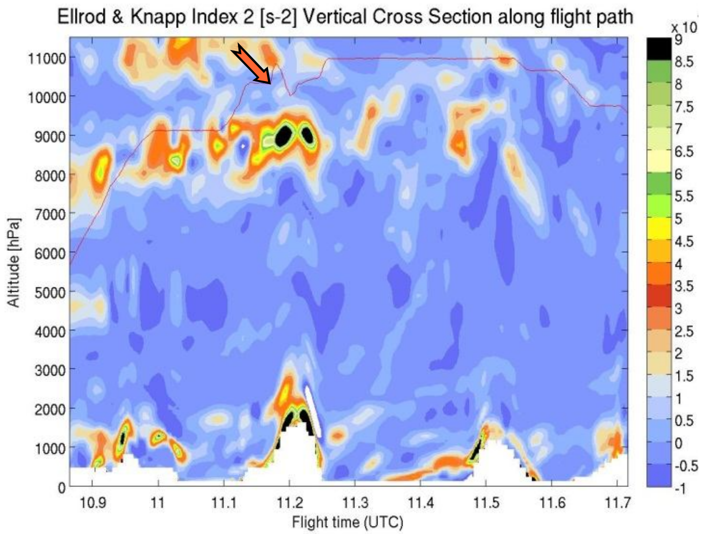
- Probable cause: Jetstream

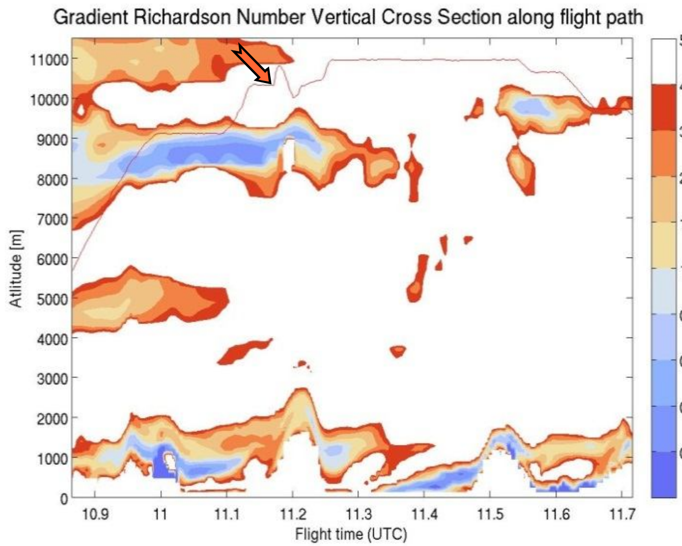


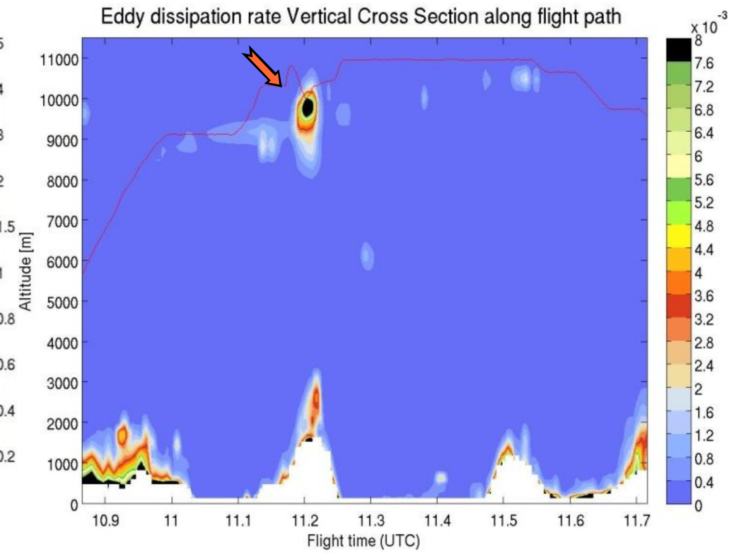




- **Turbulence indices:**
  - **TI$_2$ (Ellrod & Knapp Index 2) → deformation, shearing und divergence**
  - **RI (Gradient Richardson Number) → rate between the static stability and the vertical windshear. If RI < 1: instable**
  - **EDR (Eddy Dissipation Rate) → rate at which turbulent kinetic energy is converted into heat**







→ Turbulent spot well visible with the three indices calculated from the COSMC forecasts!

→ But signal too low (~ 1'000 m

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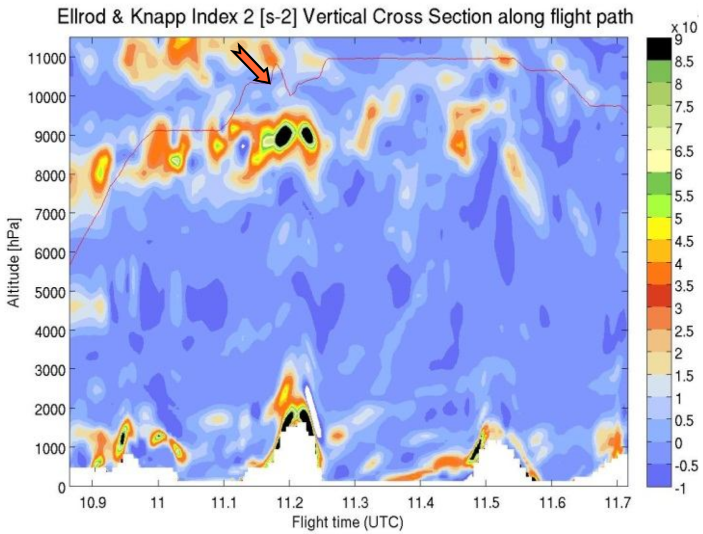
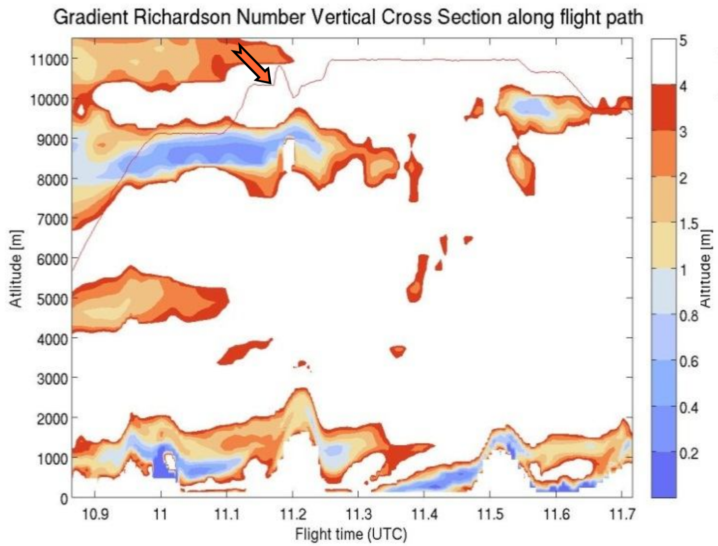
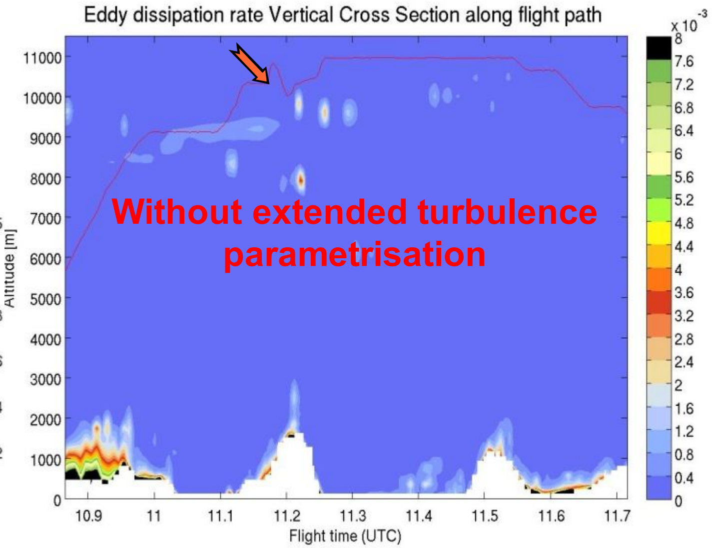




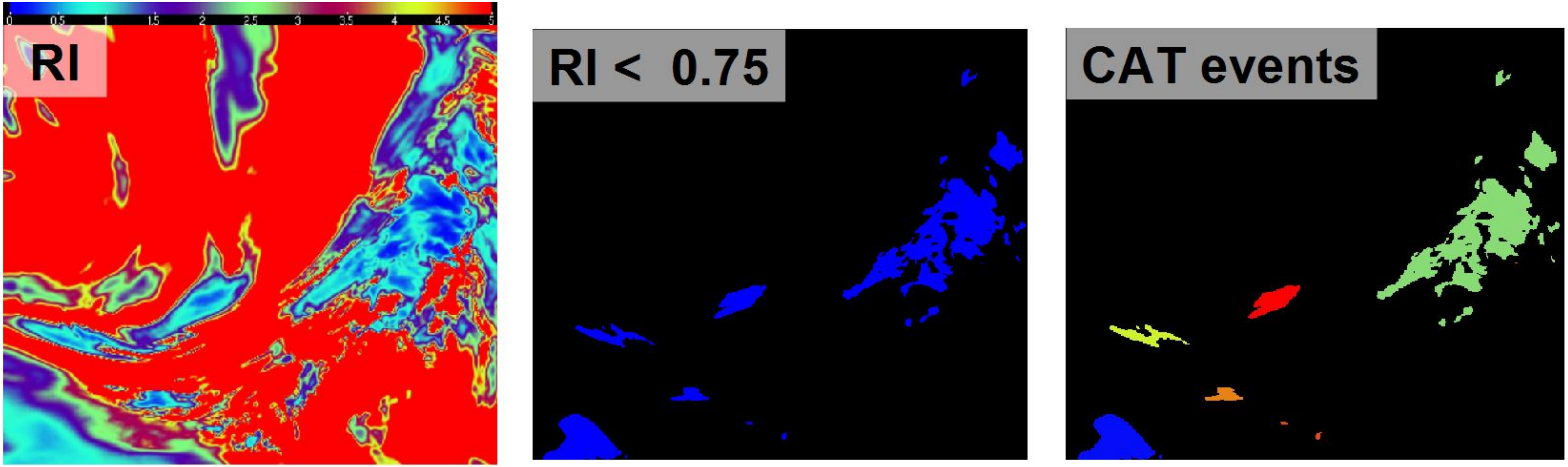


- **Extended turbulence parametrisation (SSO) is now operational: brings a significant amelioration compared to the previous scheme.**

Model - Method

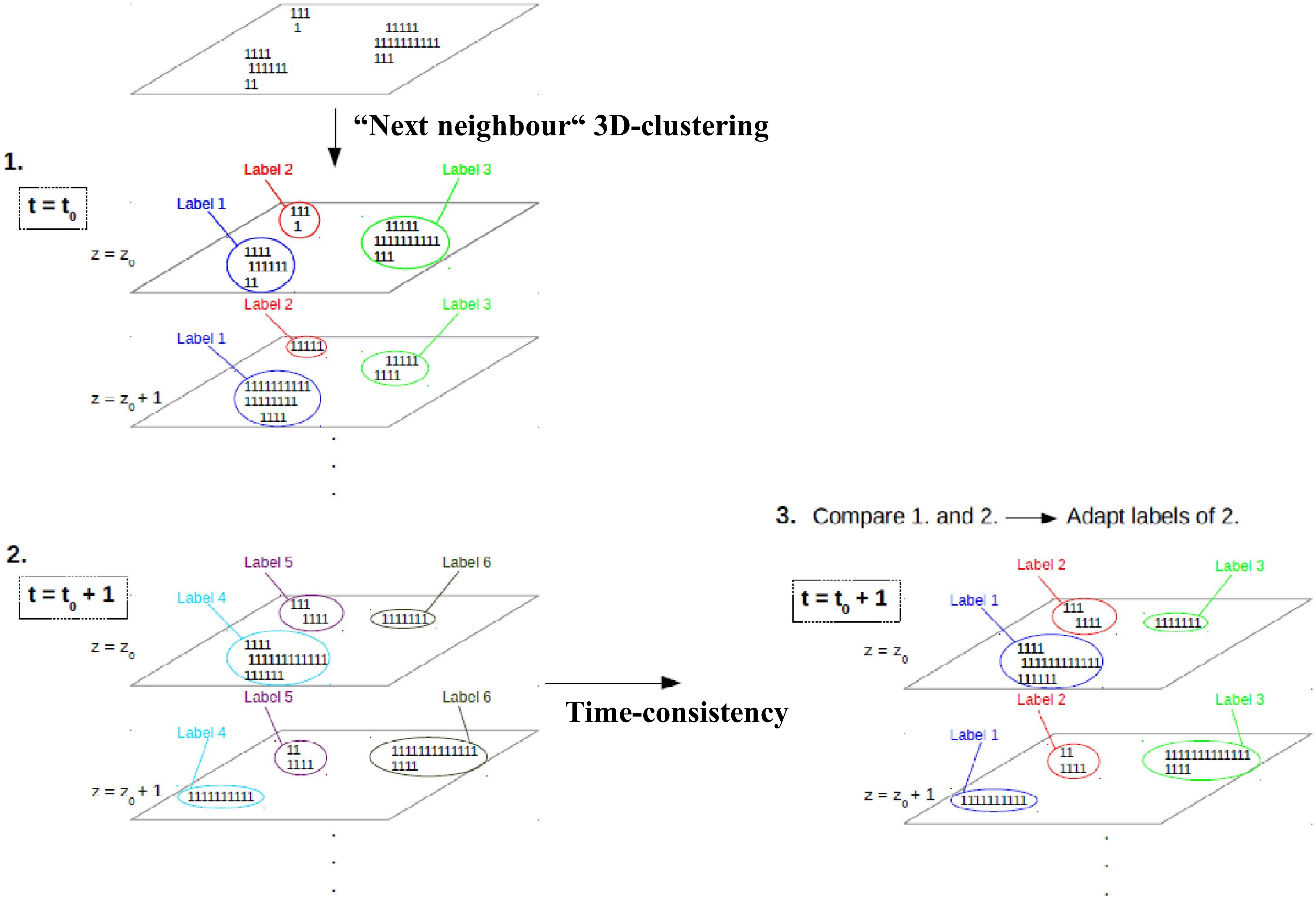
- COSMO-7 analyses for summer 2011
  - **Interpolation** on 25 height levels (6'000 – 12'000 m)
    → Reduction of the data amount
  - **Setting of threshold values** for TI_2 ($4*10^{-6}$ s^{-2}), EDR (0.07 $m^{2/3}s^{-1}$) and RI (0.75) → Selection of the turbulent regions
  - **Time-consistent 3D-Clustering:** grid points belonging to the same turbulent spot = one **Event**
    → Spatial distribution
    → Horiz./Vert. extension
    → Duration of the event
    → Lifecycle

Illustration of the method



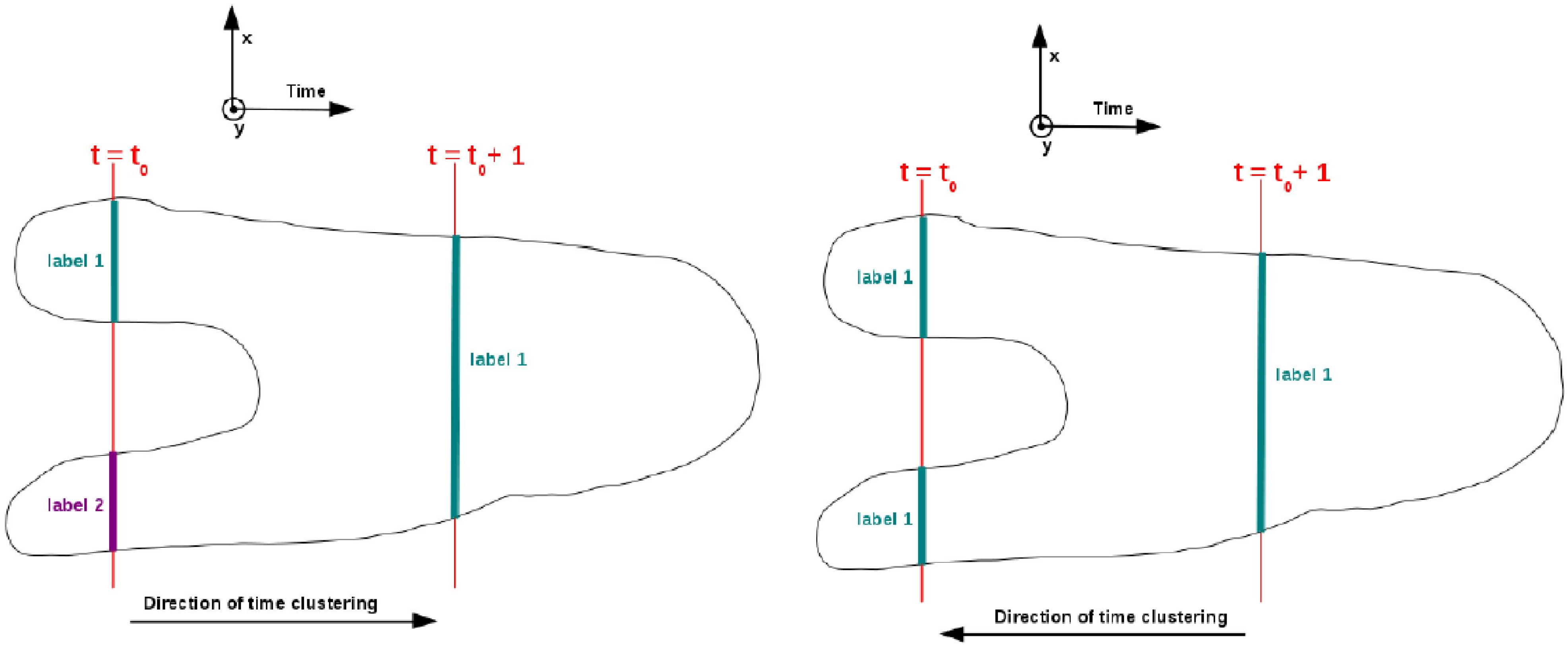
Horizontal cross sections over Europe

Clustering Algorithm



Clustering Algorithm

→ Apply also the time clustering in the other "time-direction"



Model - Results

- Some spatial and temporal characteristics of the CAT events
  - The large majority are small and short-living, only a few are very large and long-lasting
  - Differences between the indices → depends on the process described by the index

- Spatial distribution of turbulence over Europe (summer 2011)
  - Generally more frequent over land than over see (gravity waves, static instability…) and also maximum over North / North-East of Europe

Observations Data

- Flight Data Monitoring Data from Swiss (summer 2011)
- Selection criteria → 50 turb. events (out of 100'000 flights)

$$\Delta a_v > 0.8 \text{ g}$$

$$\Delta w > 1500 \text{ ft/min}$$

$$\Delta AOA > 1\ ^\circ$$

$$\Delta AOT > 1\ ^\circ\text{C}$$

$$\Delta CAS > 4 \text{ knots}$$

$$altitude > \text{FL200}$$

Observations - Results

- **Spatial distribution of the observed events depending on:**
  - → **Flight routes!**
  - → **Detection!**

Interpretation tricky!

Swiss Destination Map

Comparison Observations / Model

- **Results:**
  - **All clear detected events are associated with a large and long-lasting event from the model!**

	Detection rate
TI_2	86%
EDR	86%
RI	77%

No detection by any of the three indices	9%
Detection by all three indices	59%
Detection by at least one of the three indices	91%

Inaccuracies	Bias	
in the signal	Frequency	Mean Value
too early	19%	1 h
too late	2%	1.5 h
too high	17%	660 m
too low	17%	1090 m

Outlook

- Extend on longer period
- Require full route data from aircrafts in order to evaluate also false alarms
- Evaluate dependency of model, mainly horizontal and vertical resolution

- Met services have to tackle these challenges in close collaboration

Thank you for your attention

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