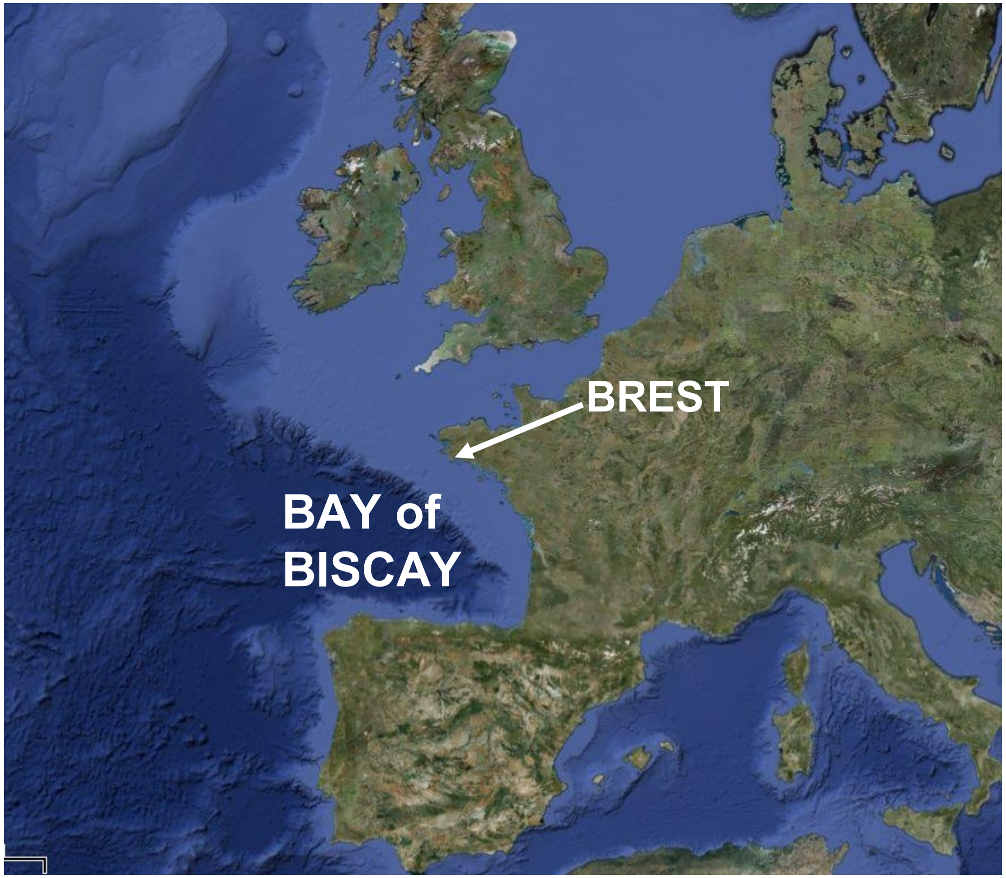
A Case Study in Forecasting Low-Lying Inversions and Stratocumulus Cloud Cover in the Bay of Biscay



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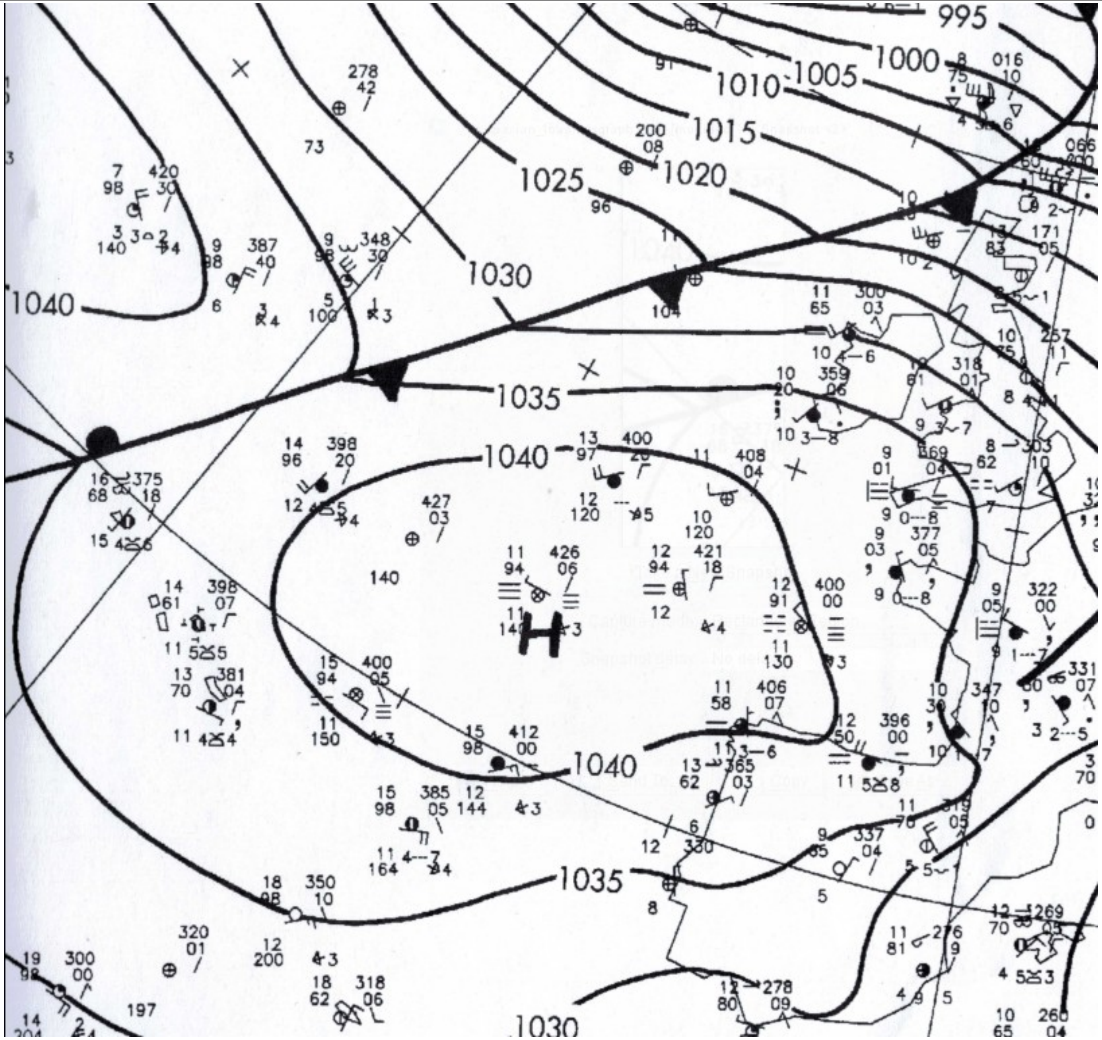
** Federal Office of Meteorology and Climatology MeteoSwiss

Situation in Bay of Biscay 27.01.2003



(Source: Surface pressure map, DWD 2003)

- Extensive high pressure system with impeding cold front

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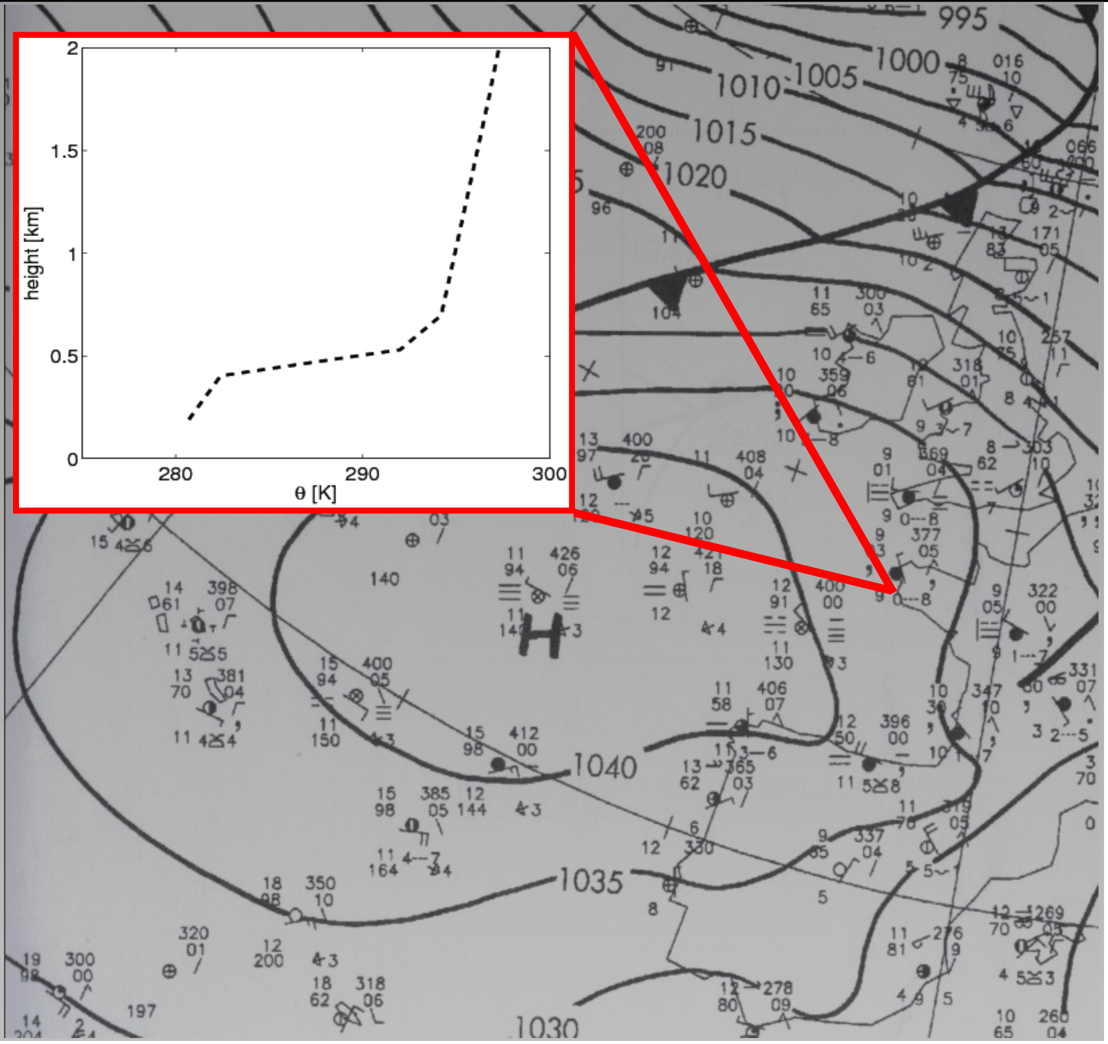

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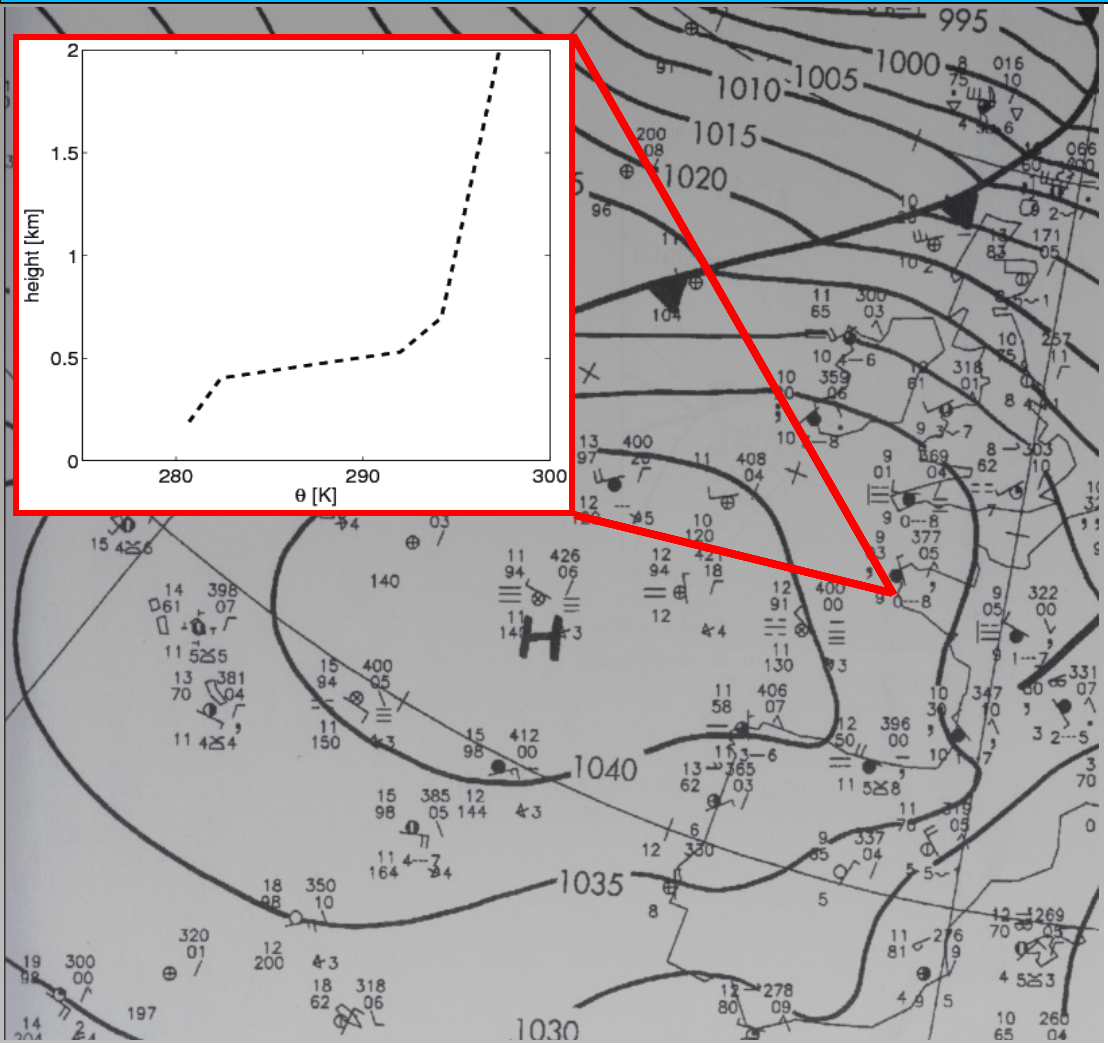

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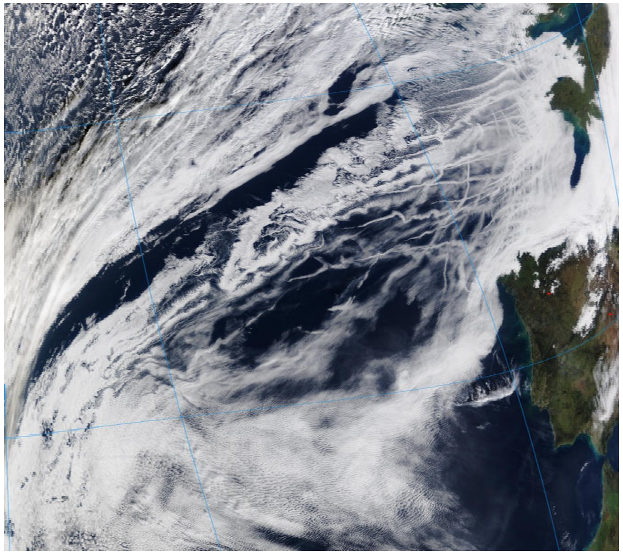
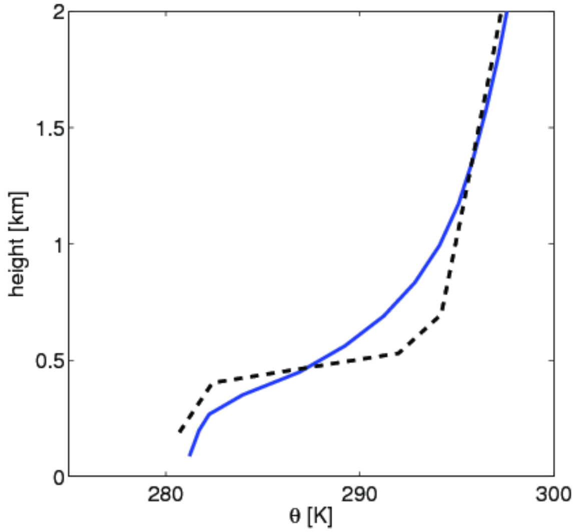
- Extensive marine stratocumulus



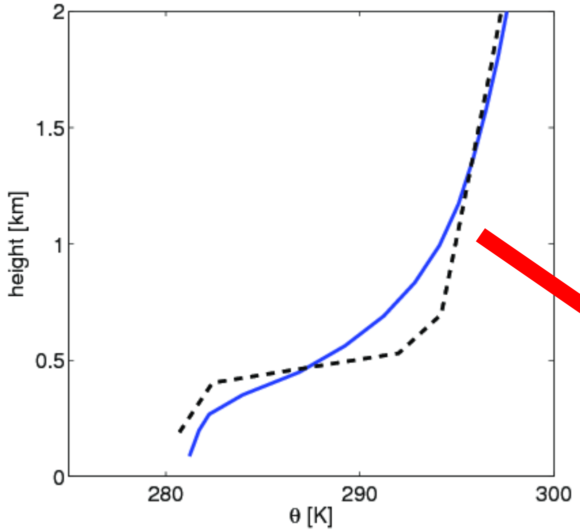
(Source: MODIS Satellite Image, Visble)

Problem



Too weak gradient in T

Problem



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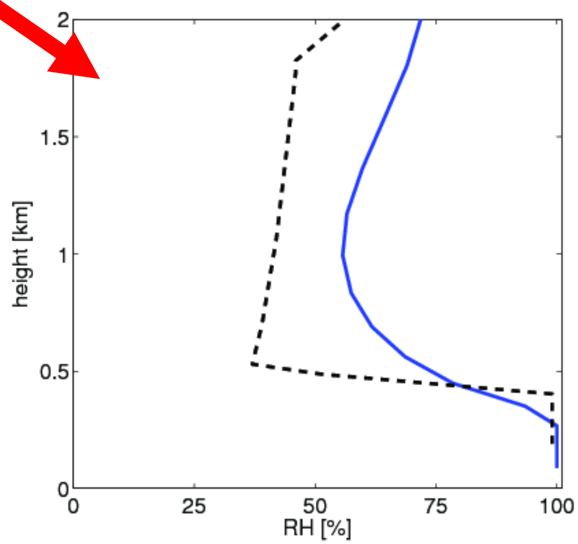
Too little moisture in PBL



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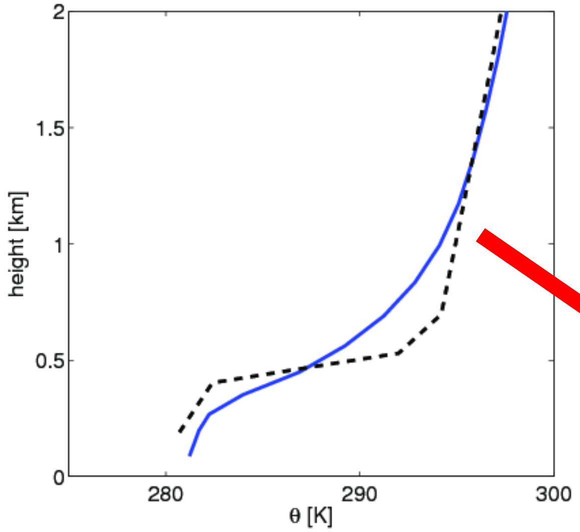

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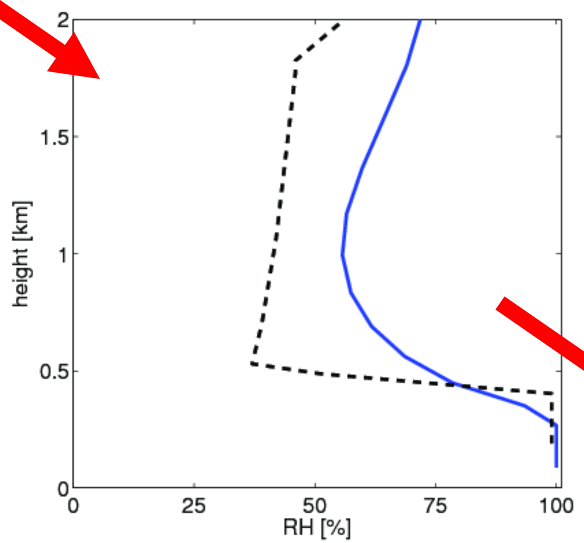
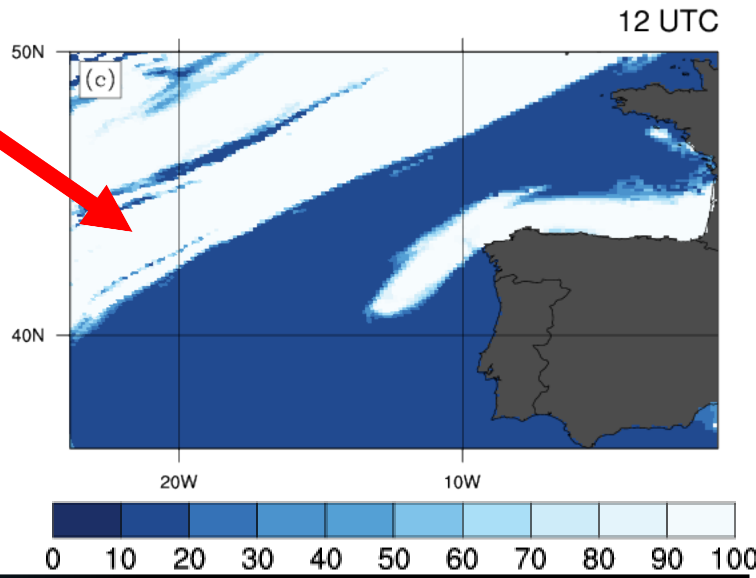


Too little moisture in PBL

VERY little cloud cover



Approach

Inversion Gradient: 12 K / 150 m

PBL Turbulence

(Raschendorfer, 2001;
Mellor and Yamada 1982,1974)

$$\overline{u'_k u'_j} = -K_M \left(\frac{\partial U_j}{\partial x_j} \right)$$

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$$\overline{u'_k q'_v} = -K_H \left(\frac{\partial Q_v}{\partial x_j} \right)$$

K_M,K_H – turb. Diffusion coefficients for momentum and heat

λ_l – maximum length scale of turbulent diffusion

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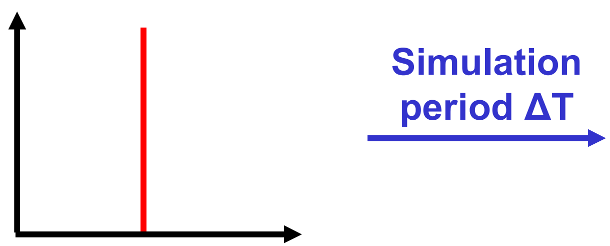

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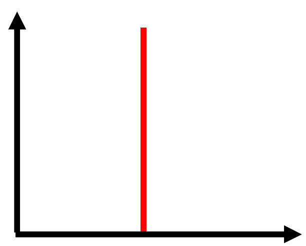
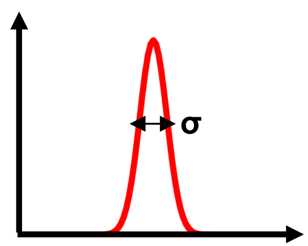


Simulation period ΔT



$F(x) = Ae(-x^2/\sigma^2)$
$\sigma^2 = 4K\Delta T$

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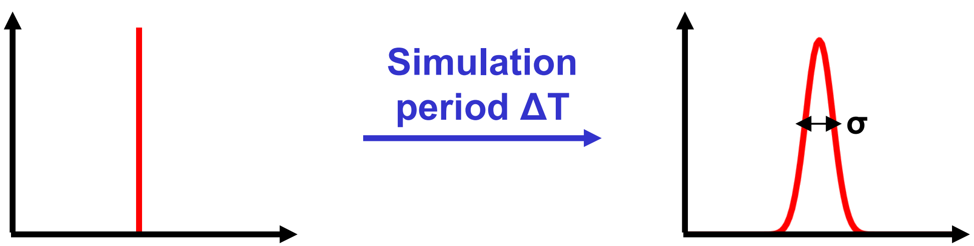
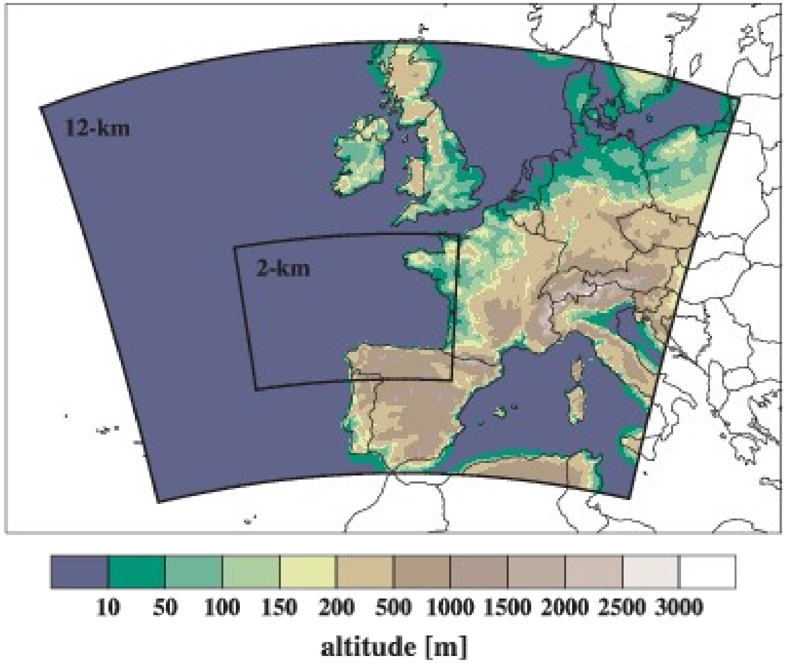


$F(x) = Ae(-x^2/\sigma^2)$
$\boldsymbol{\sigma^2 = 4K\Delta T}$

If: $K = 1\ m^2/s$, $\Delta T = 1h$, then **$\sigma = 120\ m$**

COSMO 4.14



Settings
based on MeteoSwiss Operational Setup

Radiation – Ritter and Geleyn 1992

Turbulence – TKE closure

Convection – Tiedtke 1989 (12 km simulation only)

Aerosol – Tanrè et al. 1984

Different:

Advection tracer – Semi Lagrangian Scheme

Cloud Microphysics – Seifert and Beheng 2006

Time Period:

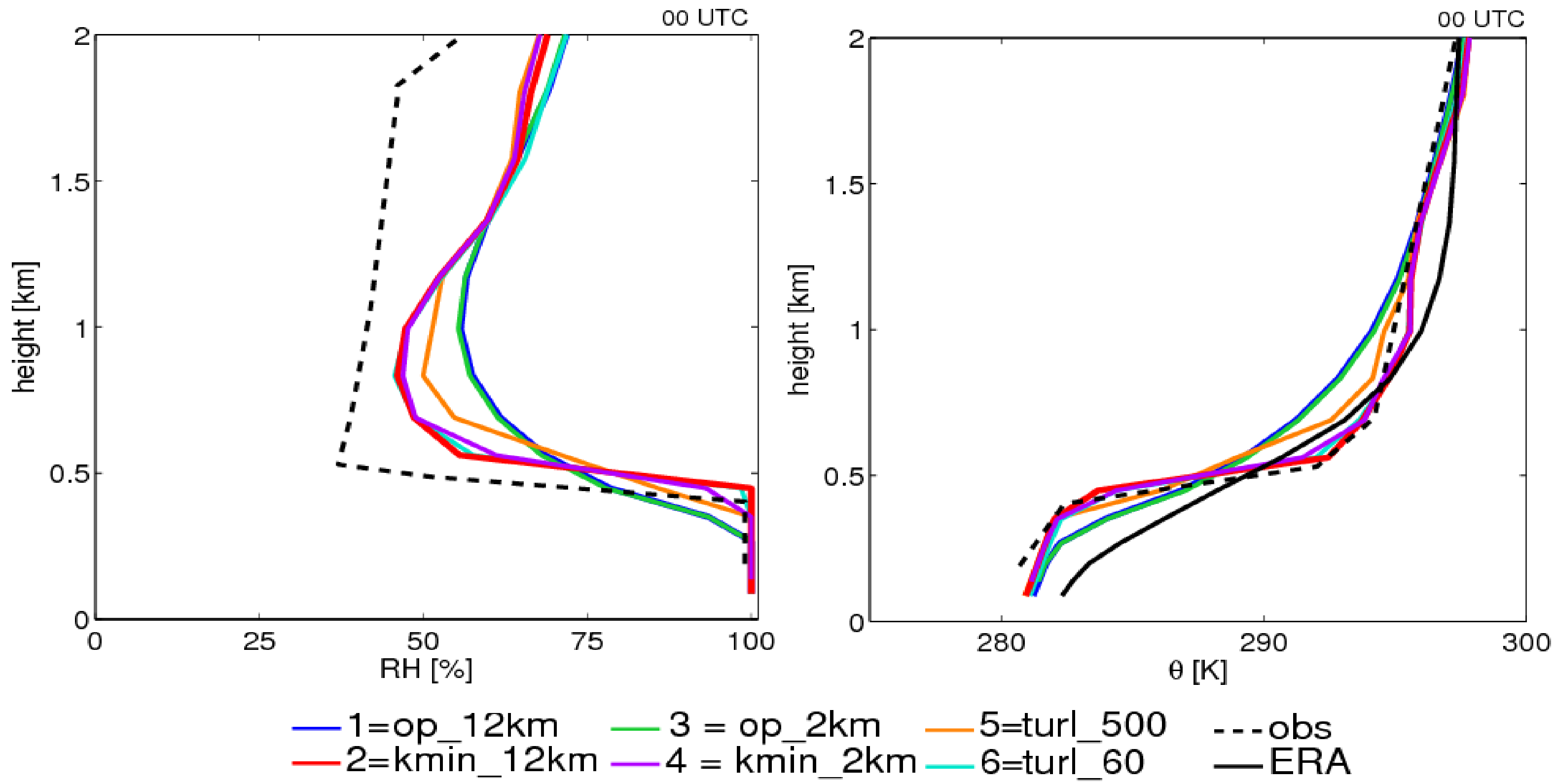
26.01.2003 00:00 – 29.01.2003 00:00

ERA-interim data → **12 km Simulation** → **2 km Simulation**

12 km Simulation
- 282 x 206 grid boxes
- 60 levels

2 km Simulation
- 350 x 250 grid boxes
- 60 levels

Results



"op" : $Min(K_M)=Min(K_H)=1\ m^2/s$

"std": $Min(K_M)=Min(K_H)=0.01\ m^2/s$

(Buzzi et al. 2011)

Results

- **12-km and 2-km simulation perform identically**
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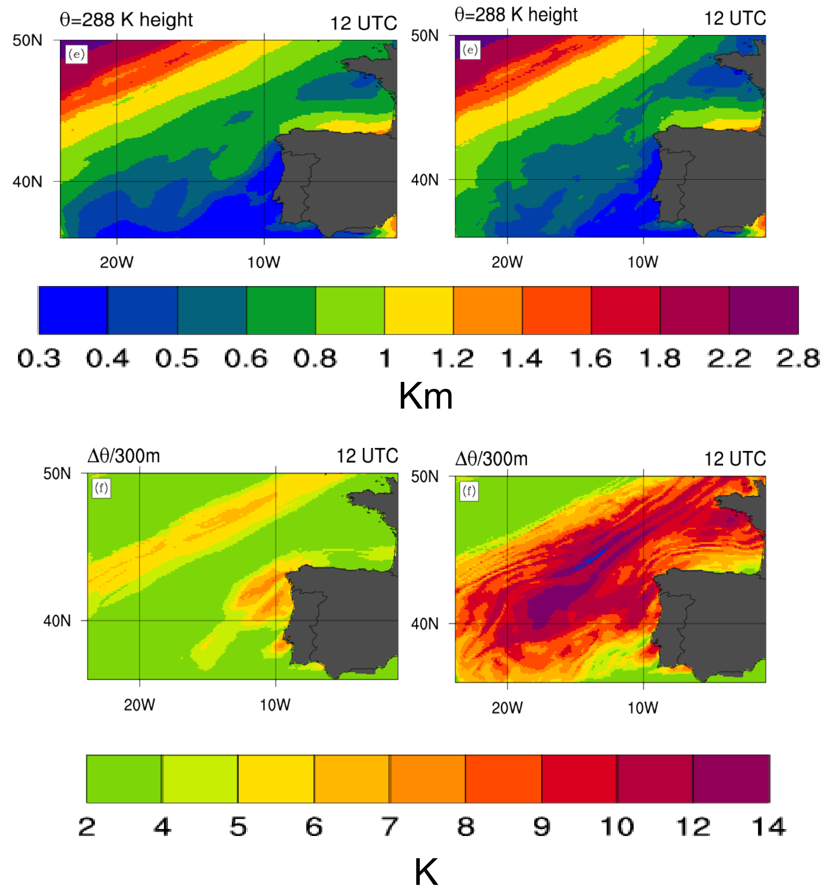
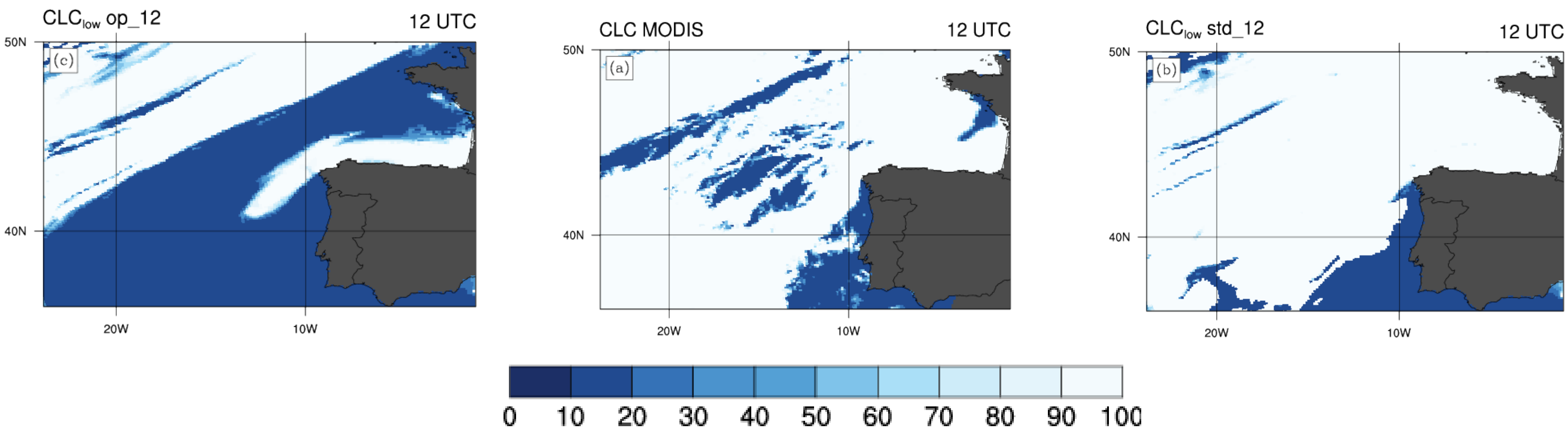


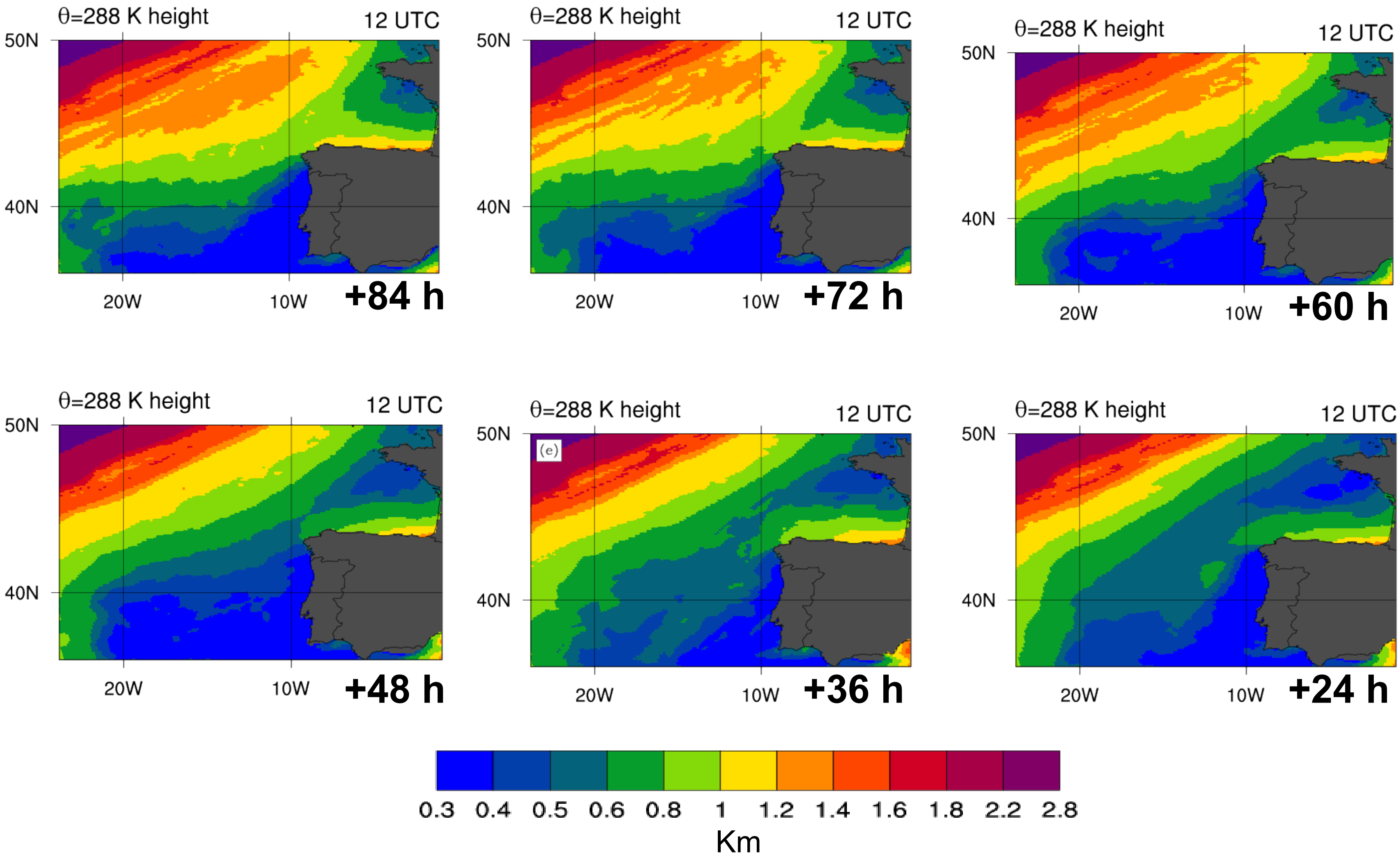
Cloud Cover



"op" : Min(K_M) = Min(K_H) = 1 m^2/s
Tur_len = 500 m

"std": Min(K_M) = Min(K_H) = 0.01 m^2/s
Tur_len = 150 m

Sensitivity to IC



Sensitivity to IC

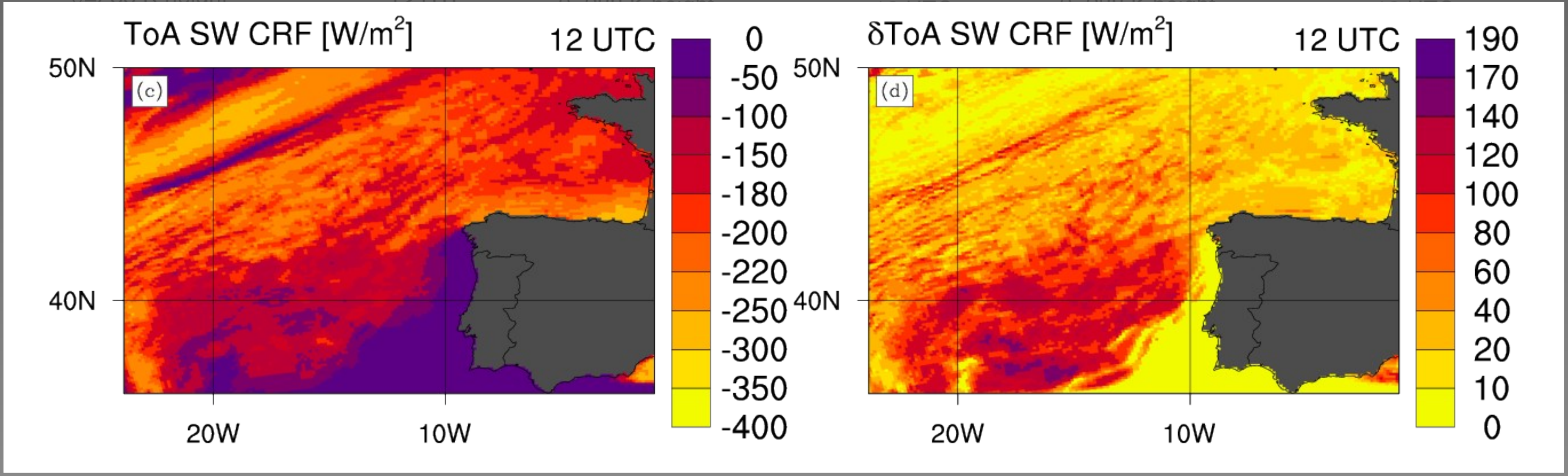
Prefrontal lifting of cold front stronger with increased lead time

↓

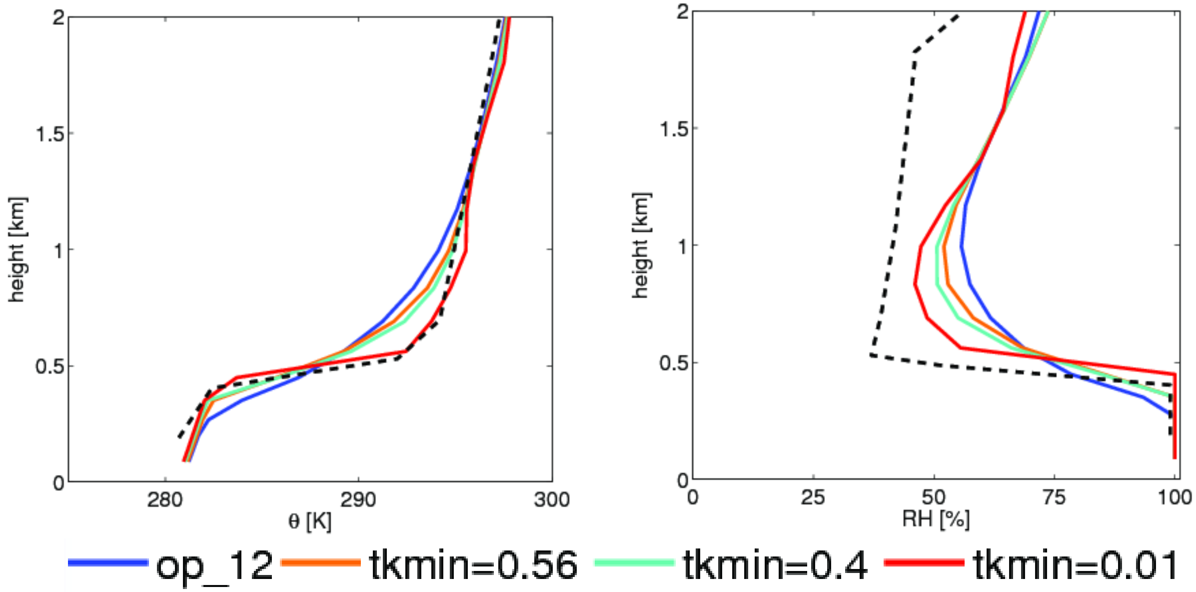
Raising of inversion height

↓

Affects cloud formation & ToA cloud radiative forcing:

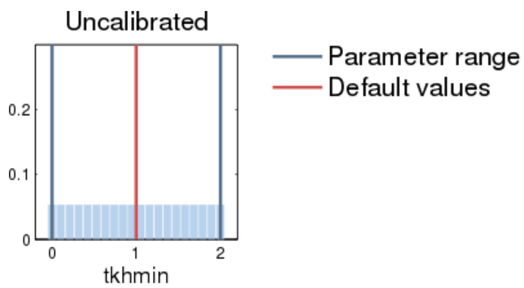


Values of Min(K_M), Min(K_H)



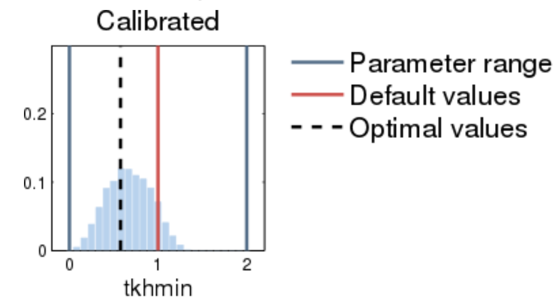
DWD

Code Version: COSMO-CLM 4.17; resolution: 0.44°
domain: CORDEX North America; period: (1992 – 1996)



Calibration for:
T_{2m}, precipitation, cloud cover

(Source: Bellprat et al. (2012))



Conclusions

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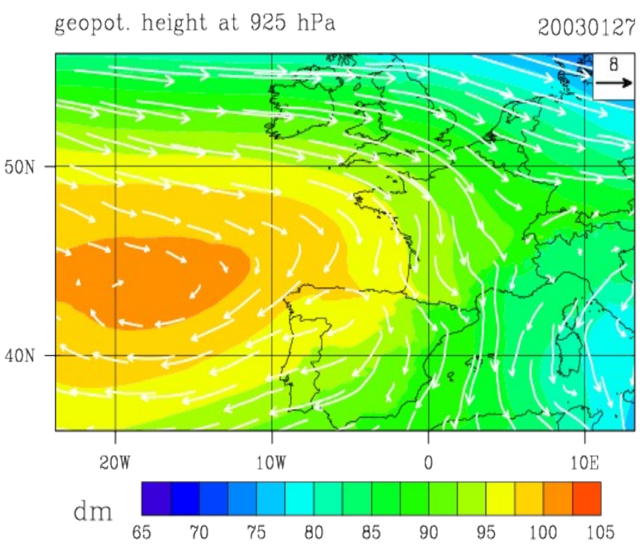
- Mesoscale (12-km) and cloud-resolving (2-km) simulations identical in forecast quality for inversion height, inversion strength and cloud distribution.

- **Turbulent vertical mixing is crucial for the thermodynamic PBL structure. PBL profiles largely sensitive to Min(K_M), Min(K_H) in stable synoptic situations.**

- **Despite evident dependency on parameterisations, nocturnal inversions of 10 - 12 K were correctly predicted with lead times between 24 – 72h .**

Approach – I/II

Large Scale Forcing Subsidence



Shallow Convection

NEGLIGIBLE

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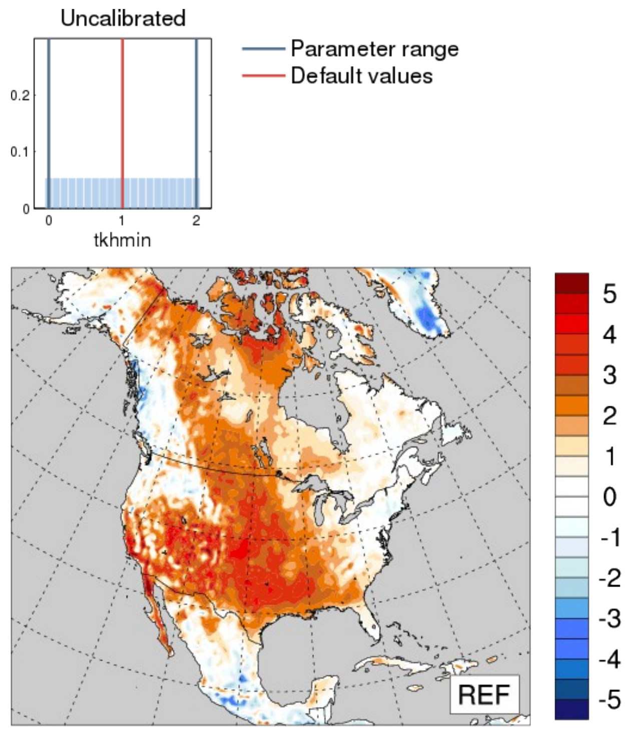
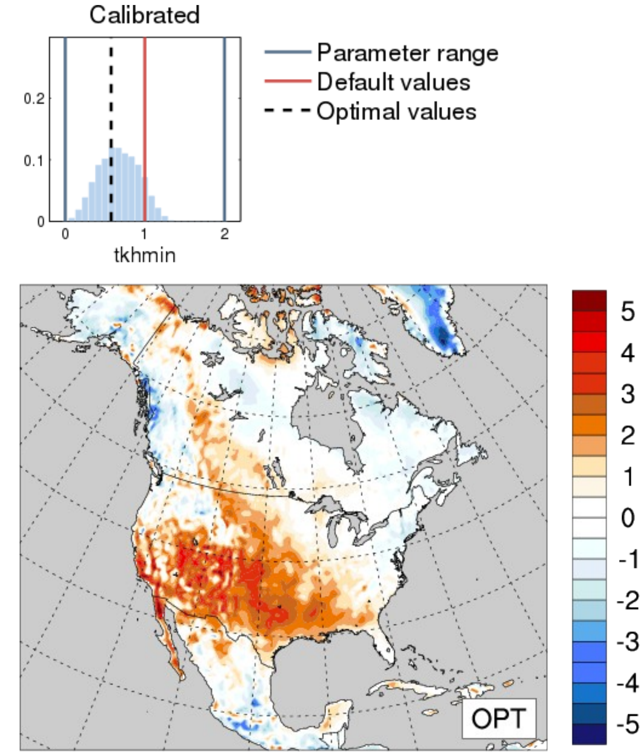
?

Objective calibration (CALMO)

- COSMO-CLM 4.17 | 0.44° CORDEX North America (1992-1996)
- Calibration for 2m temperature, precipitation, cloud cover





Bellprat, O., S. Kotlarski, D. Lüthi, and C. Schär (2012), Objective calibration of regional climate models, J. Geophys. Res., (**117**)

Problem