UNIVERSIDADE DE ÉVORA

ICT
Instituto de Ciências da Terra
Institute of Earth Sciences

NASA Jet Propulsion Laboratory
California Institute of Technology

Méso-NH simulations of Fog and Stratocumulus Clouds in Los Angeles

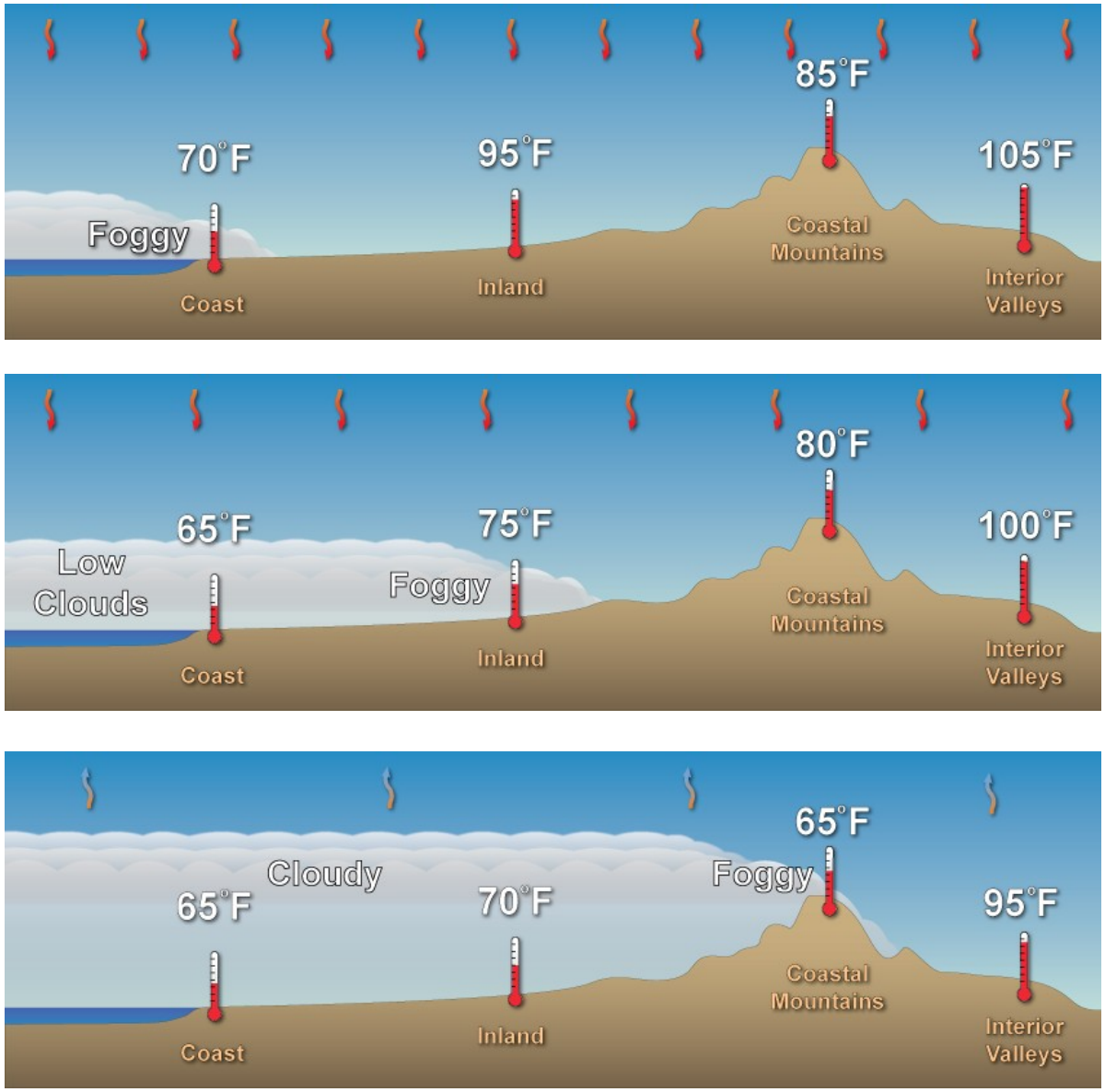
Rui Salgado (Univ. Évora)
João Teixeira, Marcin Kurowski and Kay Suselj (JPL)

Motivation

- **May Grey and June Gloom**
  - In California, people use the terms "May Grey" and "June Gloom" to describe the frequent cool, damp, overcast days during this calendar period.
  - According to Filonczuk, et al (1995) there is a 15-percent probability of fog on any given day in Los Angeles during the dry season
  - Besides California's "sunny" reputation, the presence of low stratus clouds and/or dense marine fog can cause costly slowdowns at Los Angeles International Airport, and other airports located on or near the coast.
  - the topography of the Los Angeles basin makes forecasting the marine layer more difficult for Los Angeles (and San Diego) than for locations further north along the coast.
- Test/Discuss the EDMF scheme - EDKF option in Meso-NH

On the physics of the problem

- Along the coast of California, moist air rises from the cold ocean surface and becomes trapped under dome of subsiding high pressure
- Strong downward motion from above squashes the ML and keeps is confined to the coast. Inland temperatures are high (1).
- Less downward motion -> ML move inland farther and lower inland temperatures (2)
- Slight upward motion in the upper atmosphere -> ML move well inland (3).

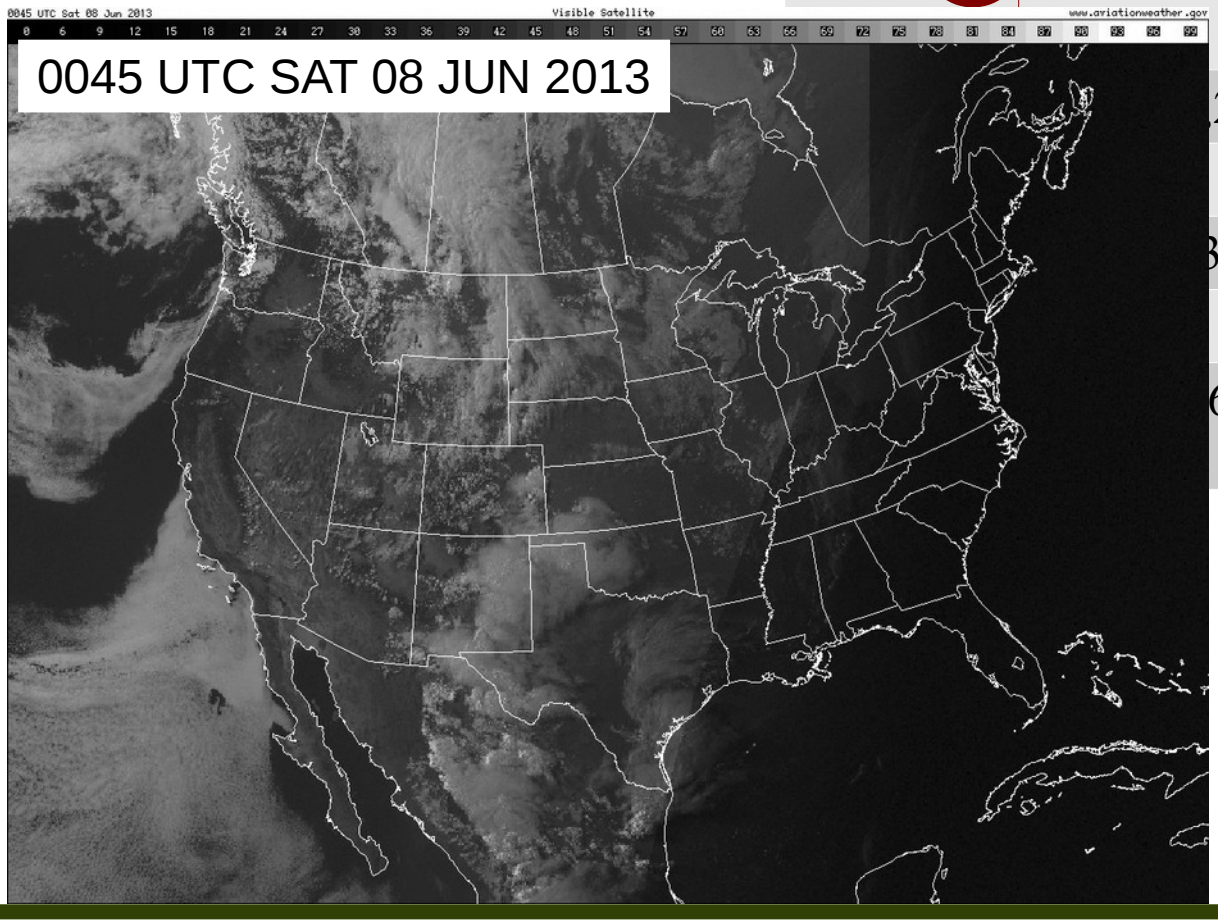


(http://www.srh.noaa.gov/jetstream/ocean/marine.html)

Methodology

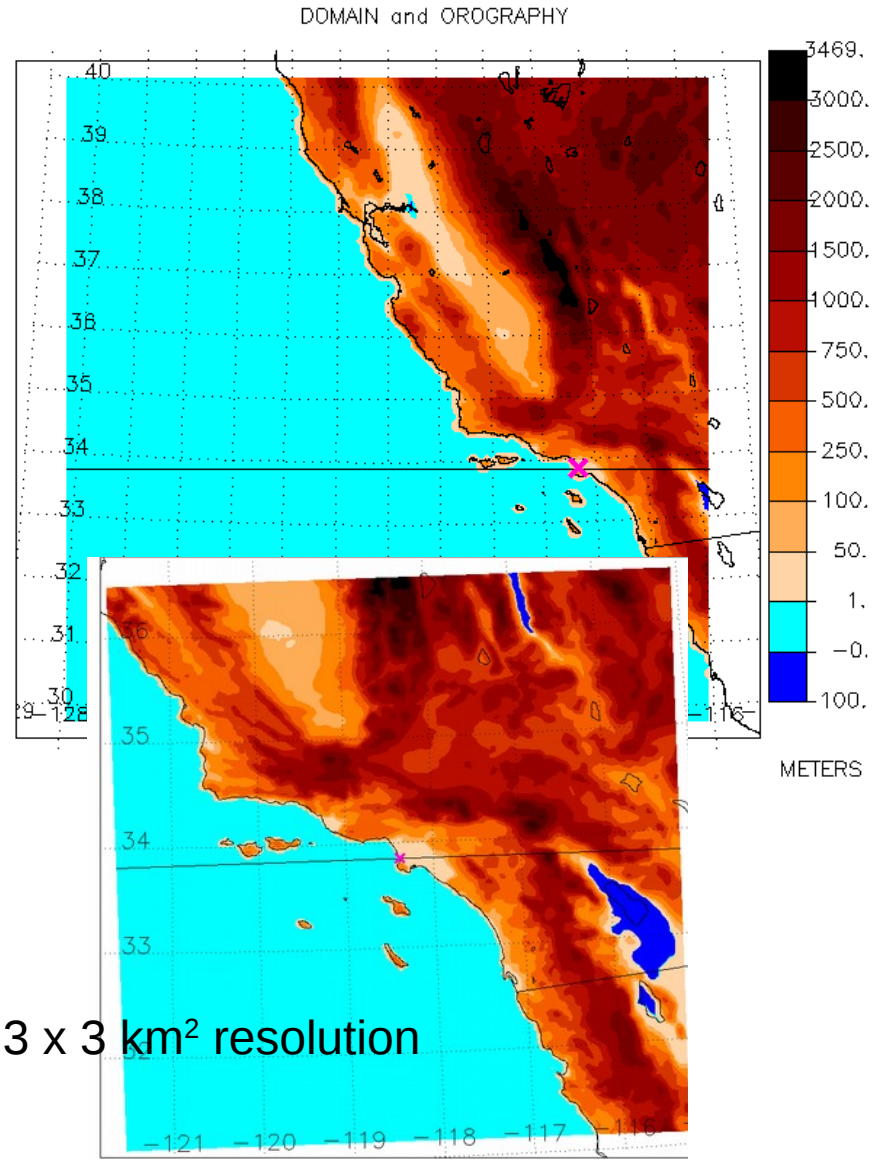
- Meso-NH simulations of case studies, selected from observations at Los Angeles Airport (LAX)
- Only the case of June 8, 2013 is shown

List of days with fog reported at the LAX during last Junes (in red several strong events) **2013**
01, 07, 08, 12, 13 14, 17, 18, 25, 26, 27, 28 e 29
23,25,26 e 30
3, 14, 15, 16, 17, 18, 19, 20, 21, 25,26
6, 07, 08, 09, 10, 14, 22, 24, 25, 26, 27, 28,



Model setup

9 x 9 km² resolution



3 x 3 km² resolution

Meso-NH version 5.3 with WENO

72 vertical levels (10m → 20km)

Physics:

Surface: SURFEX

Radiation: ECMWF

Turbulence: 1D

Clouds microphysics: ICE3

Deep convection: No

Shallow convection: Eddy-Diffusivity-Kain-Fritsch, (EDKF) – yes and no

Surface databases:

Land cover: Ecoclimap

Orography: GTOPO30;

Texture: Clay and Sand (FAO)

The model was initialized and forced by 6-hourly ECMWF analysis.

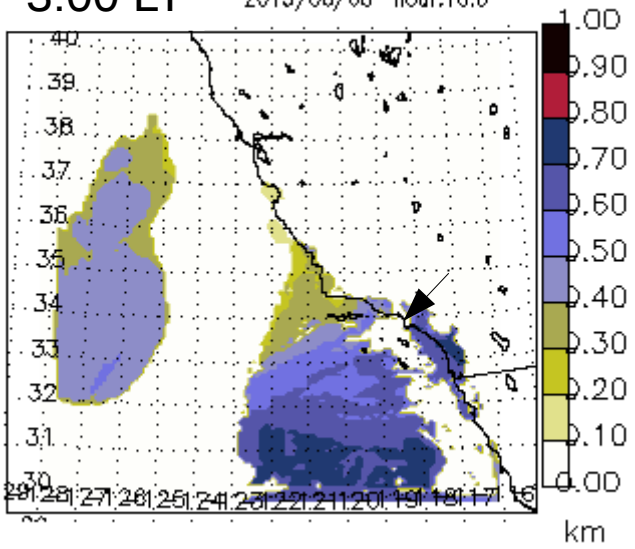
Validation

- Against surface observations from both manual and automated (AWOS, ASOS) stations
  - from the NCDC Local Climatological Data (LCD) database (hourly data) (shown only cloud cover comparison over LAX)
- Radiosounds (Saint Diego)
  (not shown)
- Images from geostationary Satellite, GOES visible
  (shown several examples)
- The simulation at 9x9 km with EDKF was used to do the comparisons

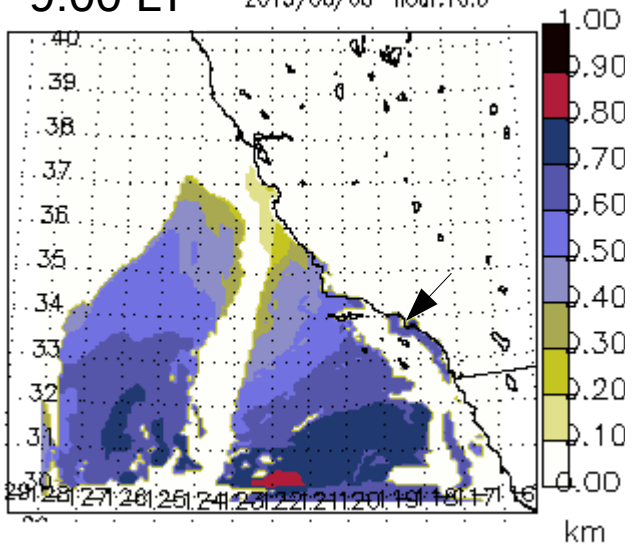
Evolution of the cloud cover

Cloud top height - HECL

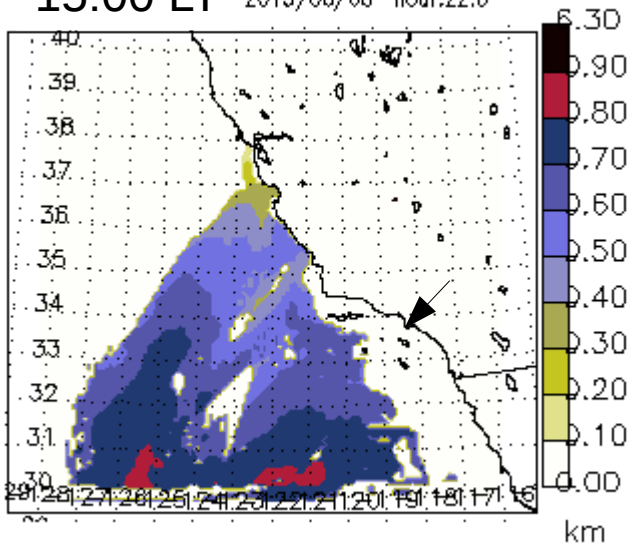
3:00 LT



9:00 LT

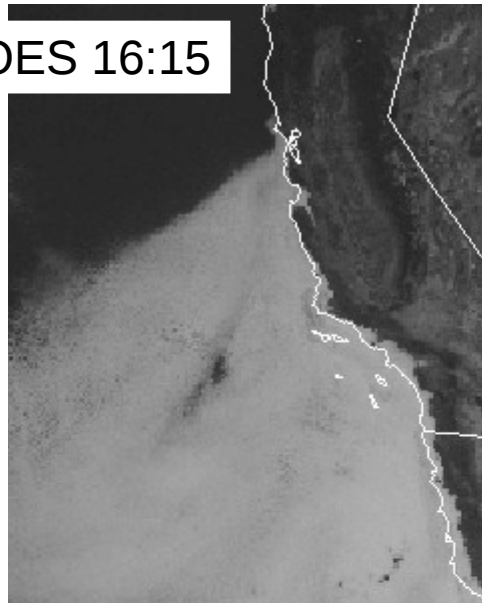


15:00 LT

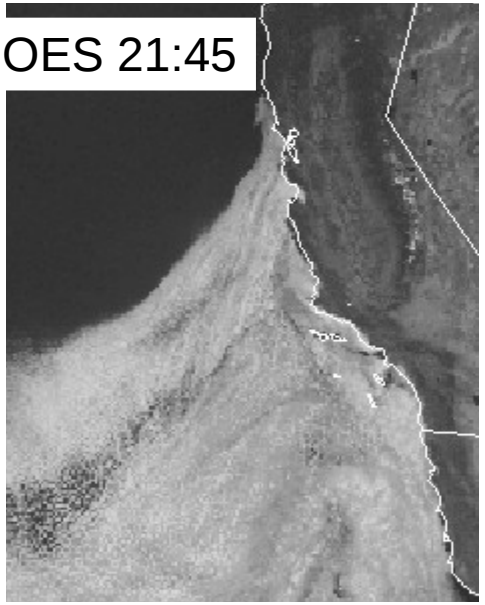


- The pattern of cloud cover is similar to observed (image satellite geostationary - visible)
- But, cloud cover is underestimate, in particular in afternoon in south of Los Angeles

GOES 16:15



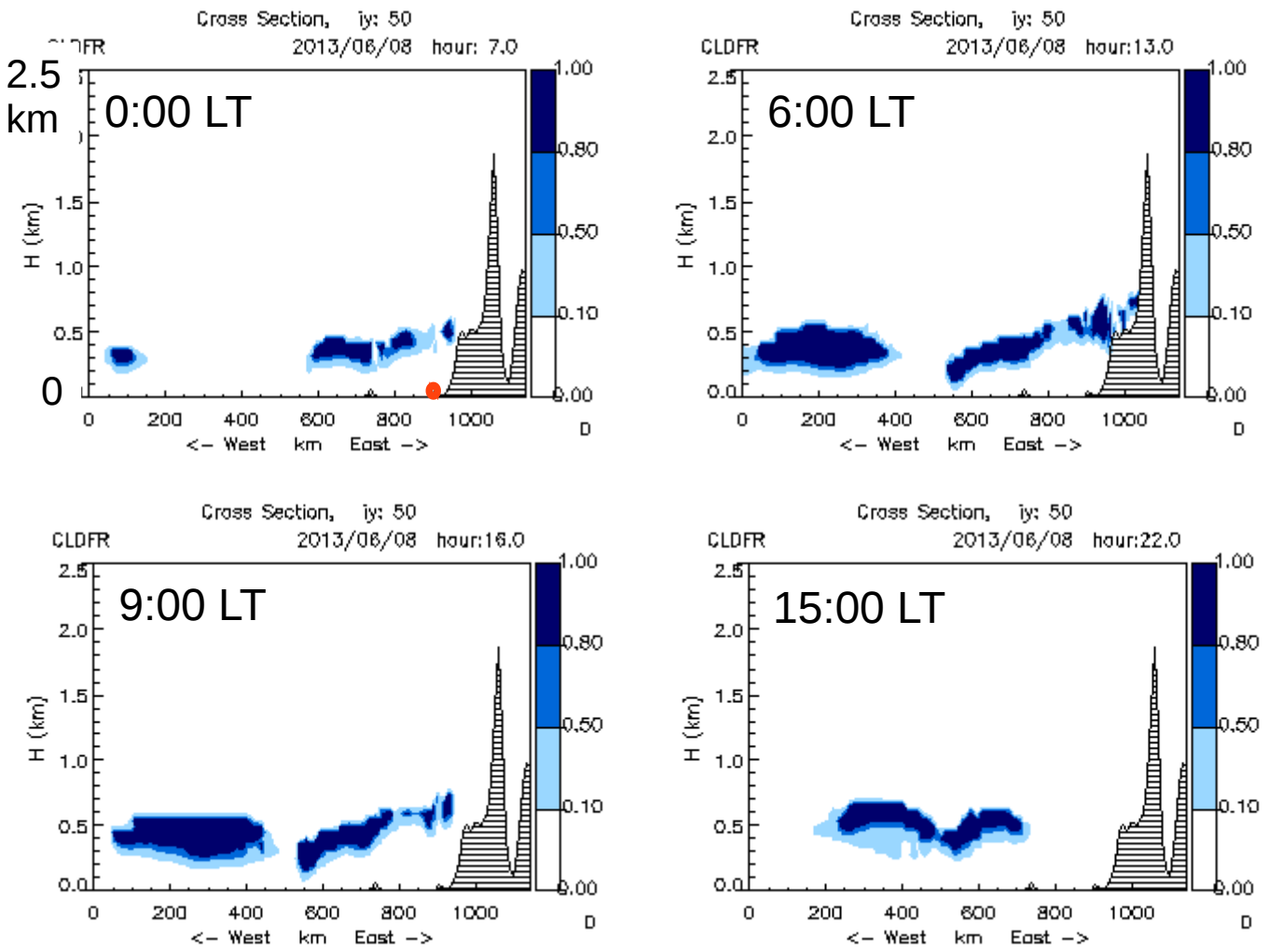
GOES 21:45



Results: Cross section of cloud fraction

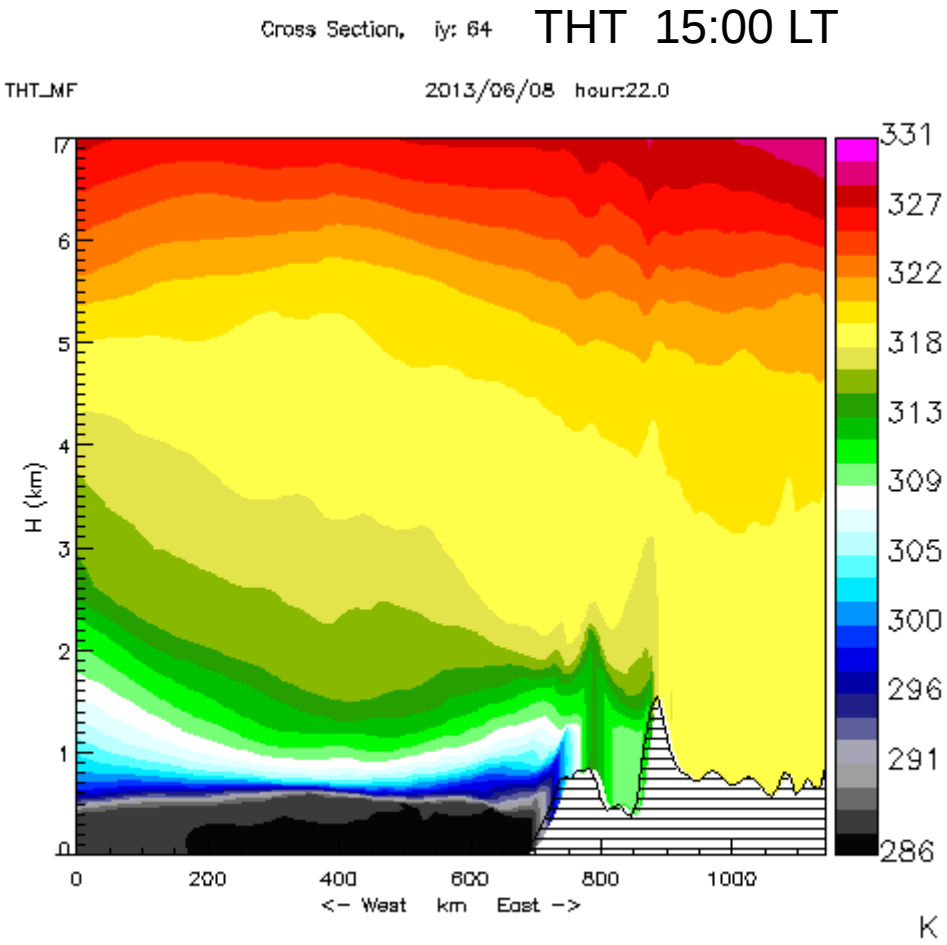
- W-E cross section passing over LA (orange point)
- low and thin clouds, base at ~200m, top at ~500 m
- Maximum extension over land 6:00 LT
- No clouds over land in the afternoon

CLDFR



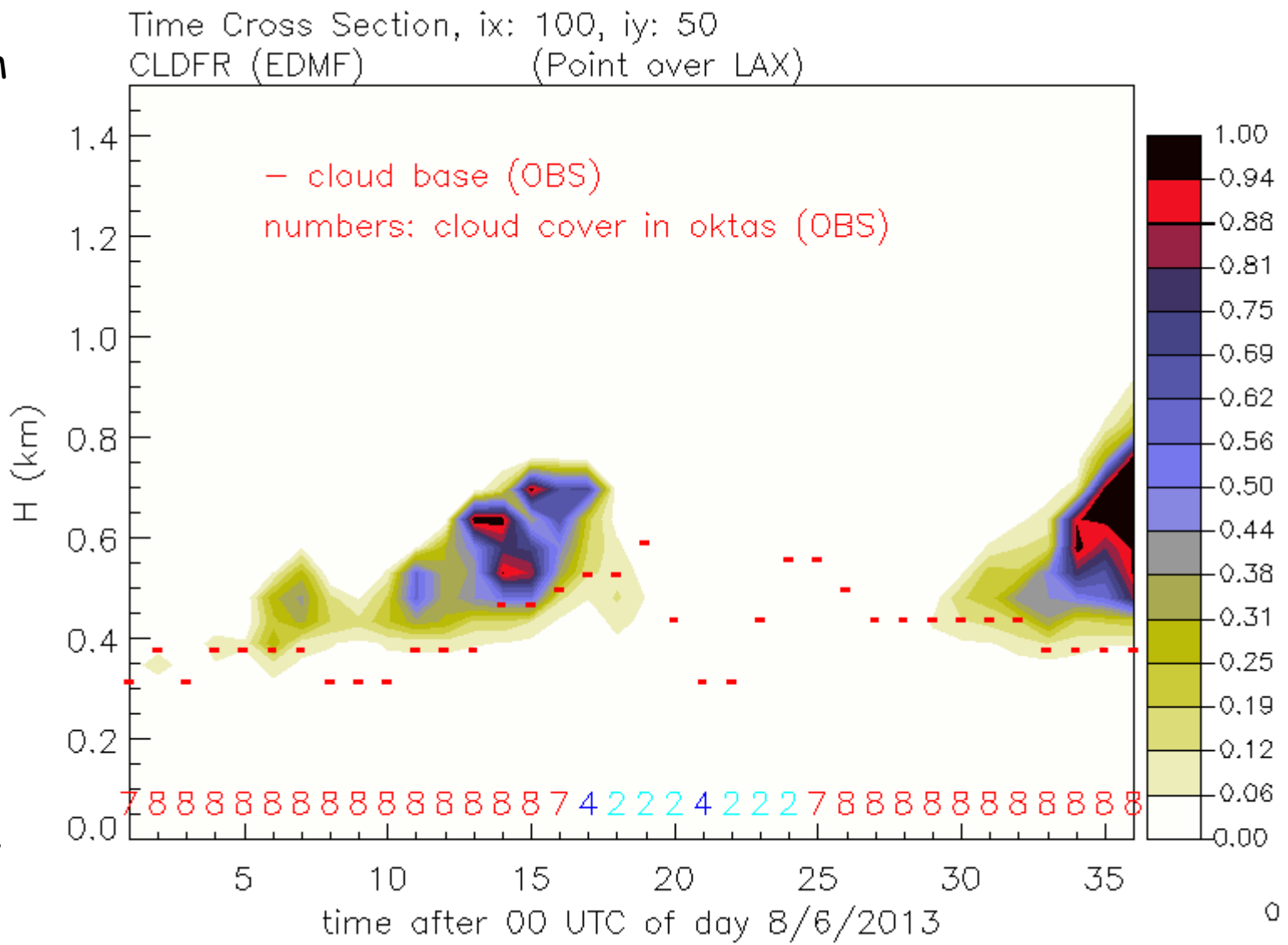
Potential temperature cross section

The cross section (W-E) of potential temperature has the signature of the mechanism that crate the low level clouds: the downward motion from above squashes the cold and moist Marine Layer and keeps it confined to the coast.



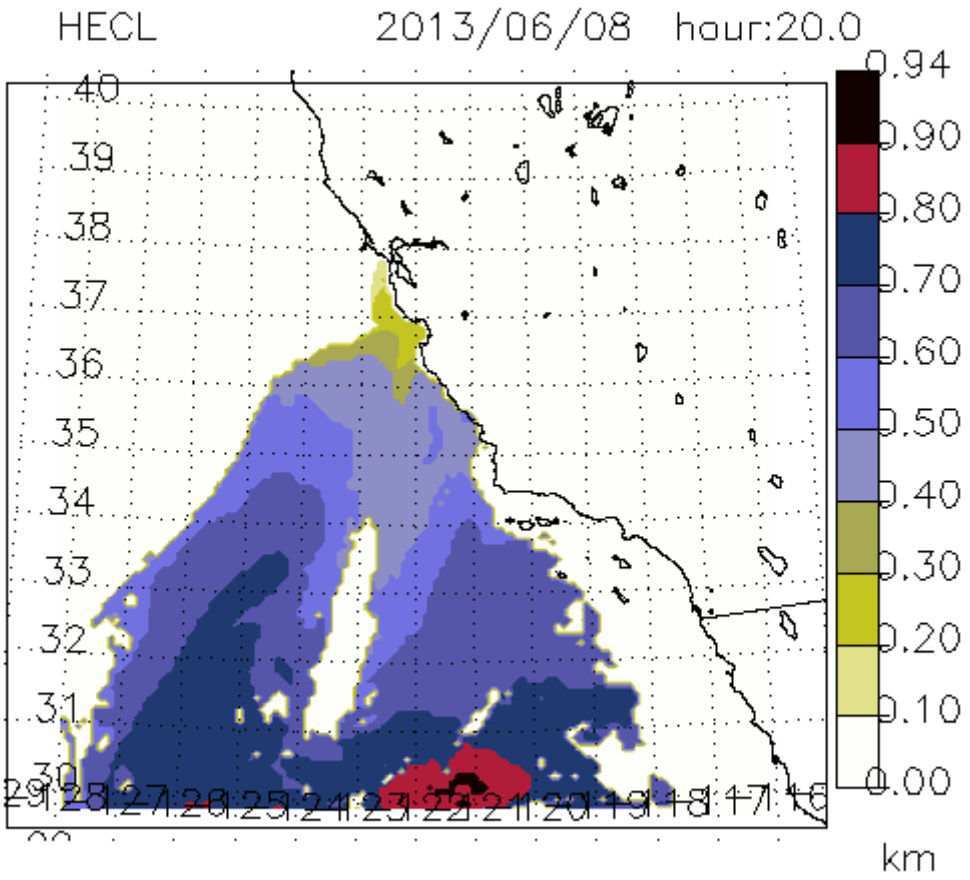
Evolution of cloud profile over LAX

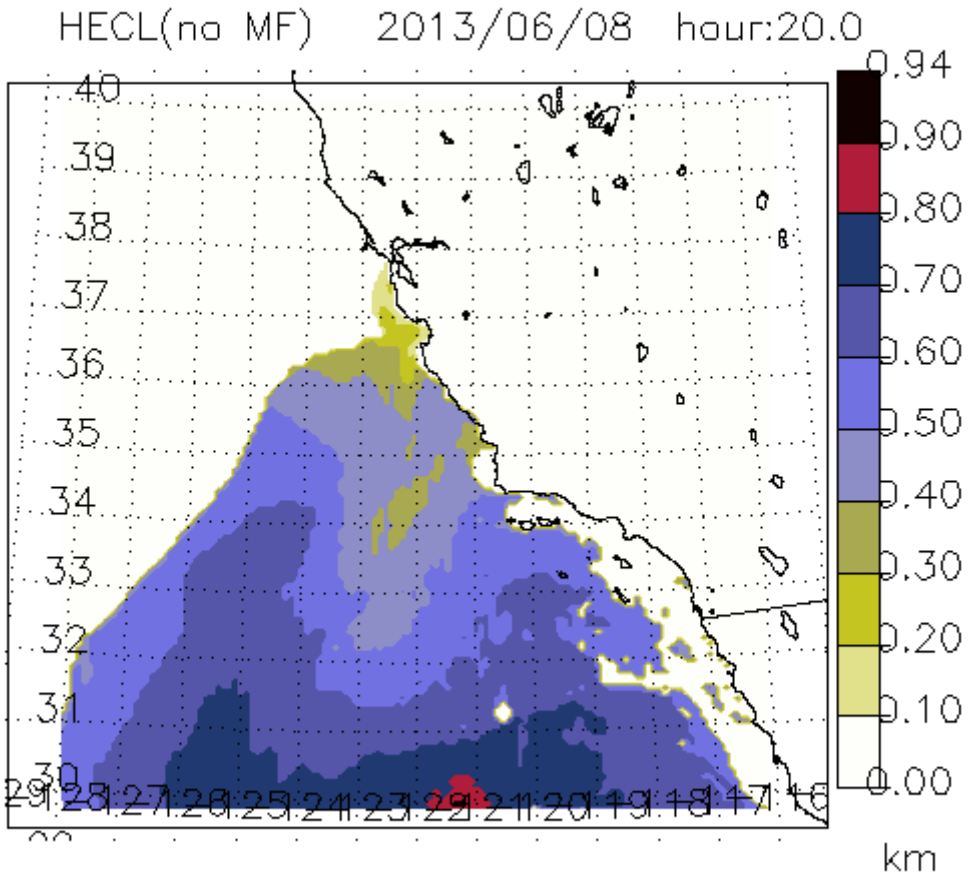
- Time – height, Hovmöller diagram evolution of cloud fraction profile over the Airport.
- Observed cloud cover (oktas) in numbers (in red when ge 5)
- Observed height of cloud base in red dashes
- **The agreement between the observations and the model is very good!**



Comparison EDMF / no EDMF

Cloud top height - HECL 13:00 LT

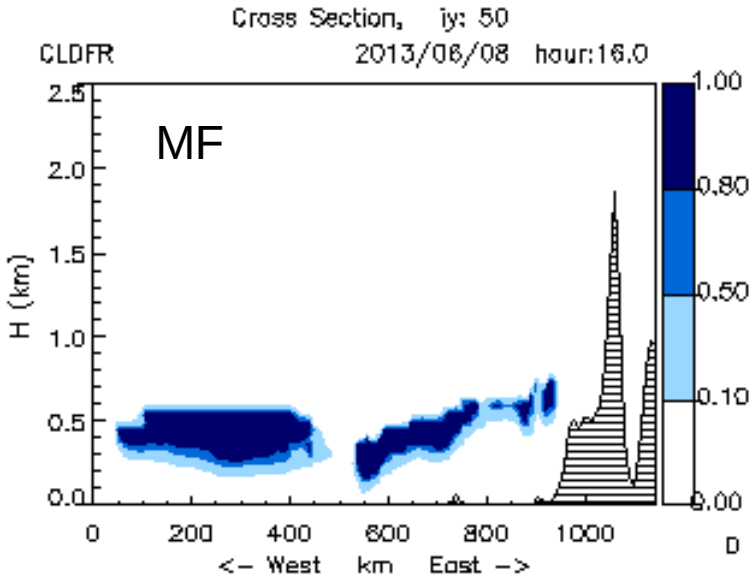


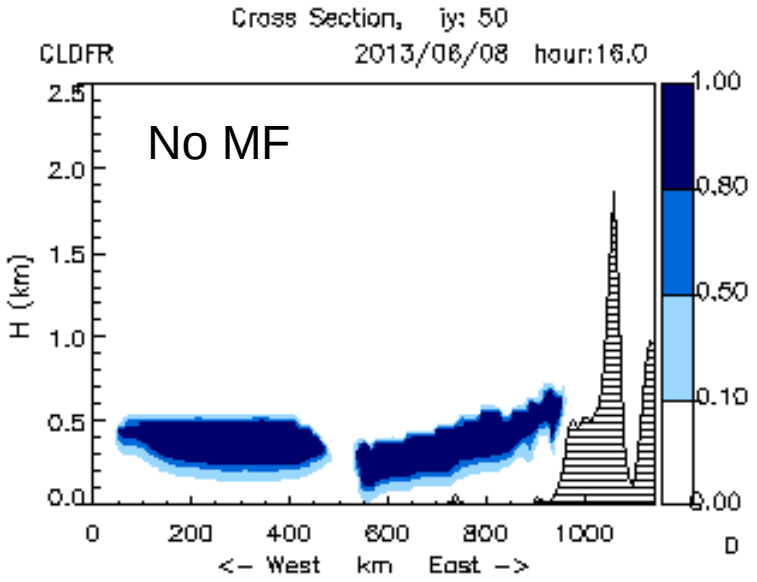


Without the activation of the EDKF scheme, the area covered by clouds is larger and is more close to the satellite observed area.

Comparison EDMF / no EDMF (2)

CLDFR W-E Cross section 9:00 (LT)



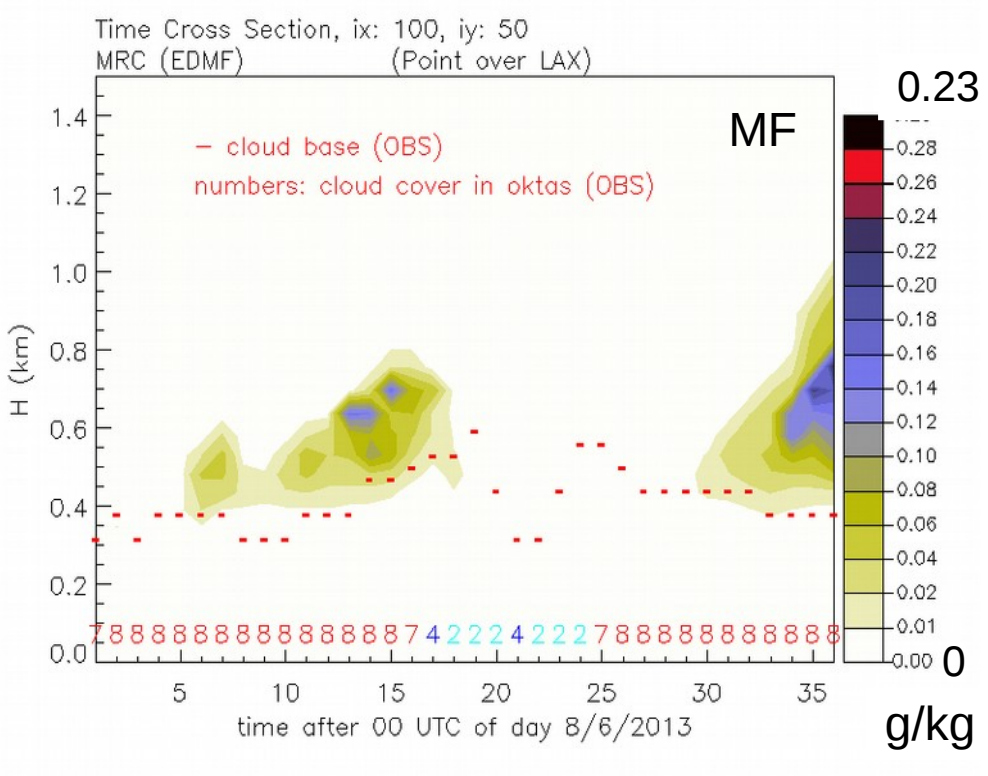


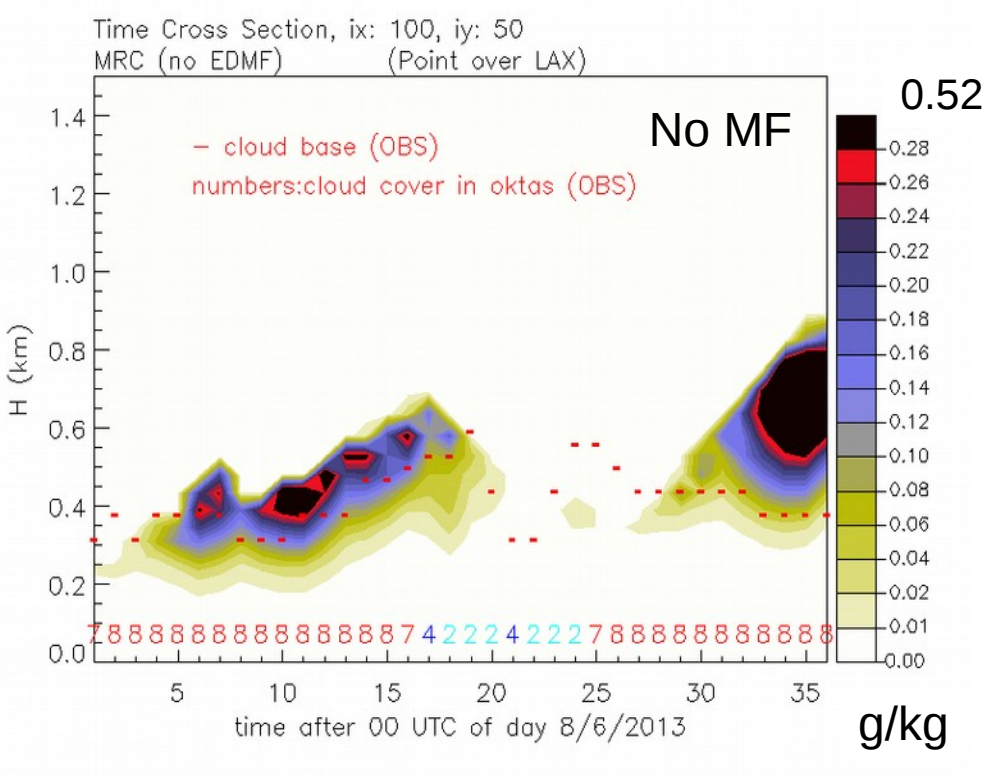
But with the EDKF scheme, close to the coast, clouds are tinner and higher

Evolution of cloud profile over LAX

9 x 9 km resolution

MRC – Cloud water mixed ratio

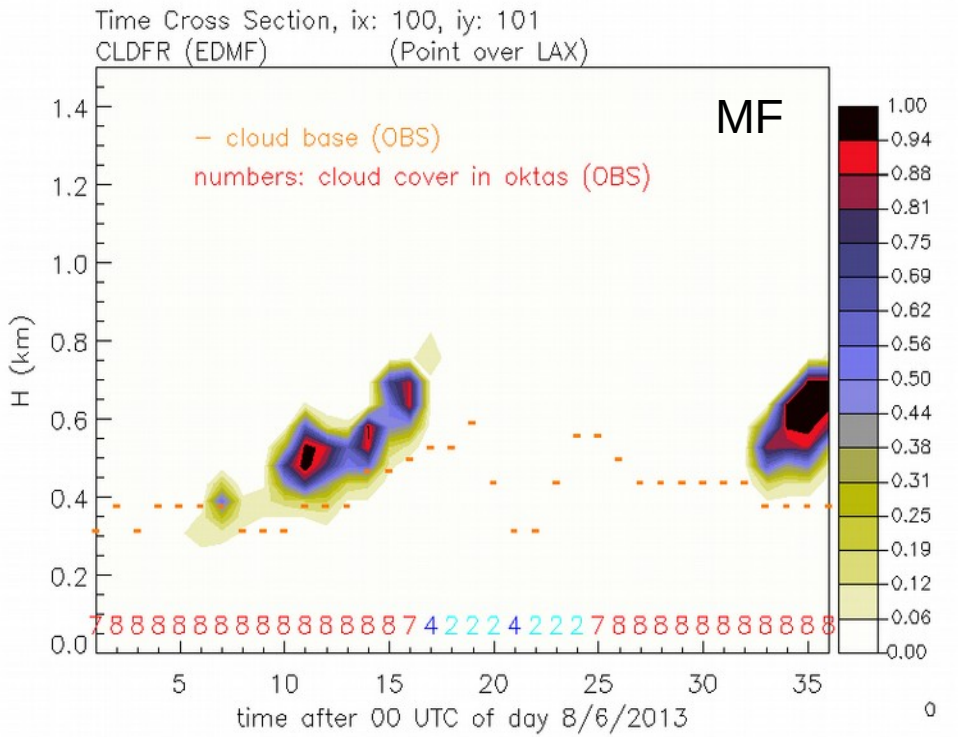


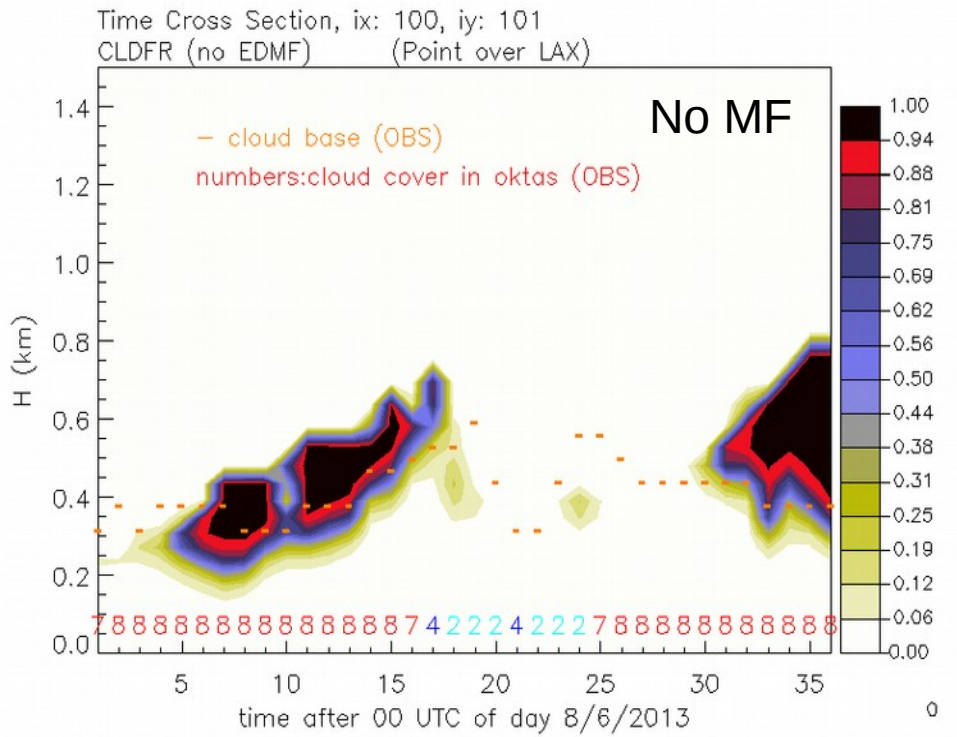


The height of the cloud base seems to be better represented in the simulation with the EDKF scheme (the similarity of model and observations is fantastic!).
However in the simulation with EDMF the appearance of clouds over the airport at late afternoon seems to be delayed.

Evolution of cloud profile over LAX (3x3)

3 x 3 km resolution





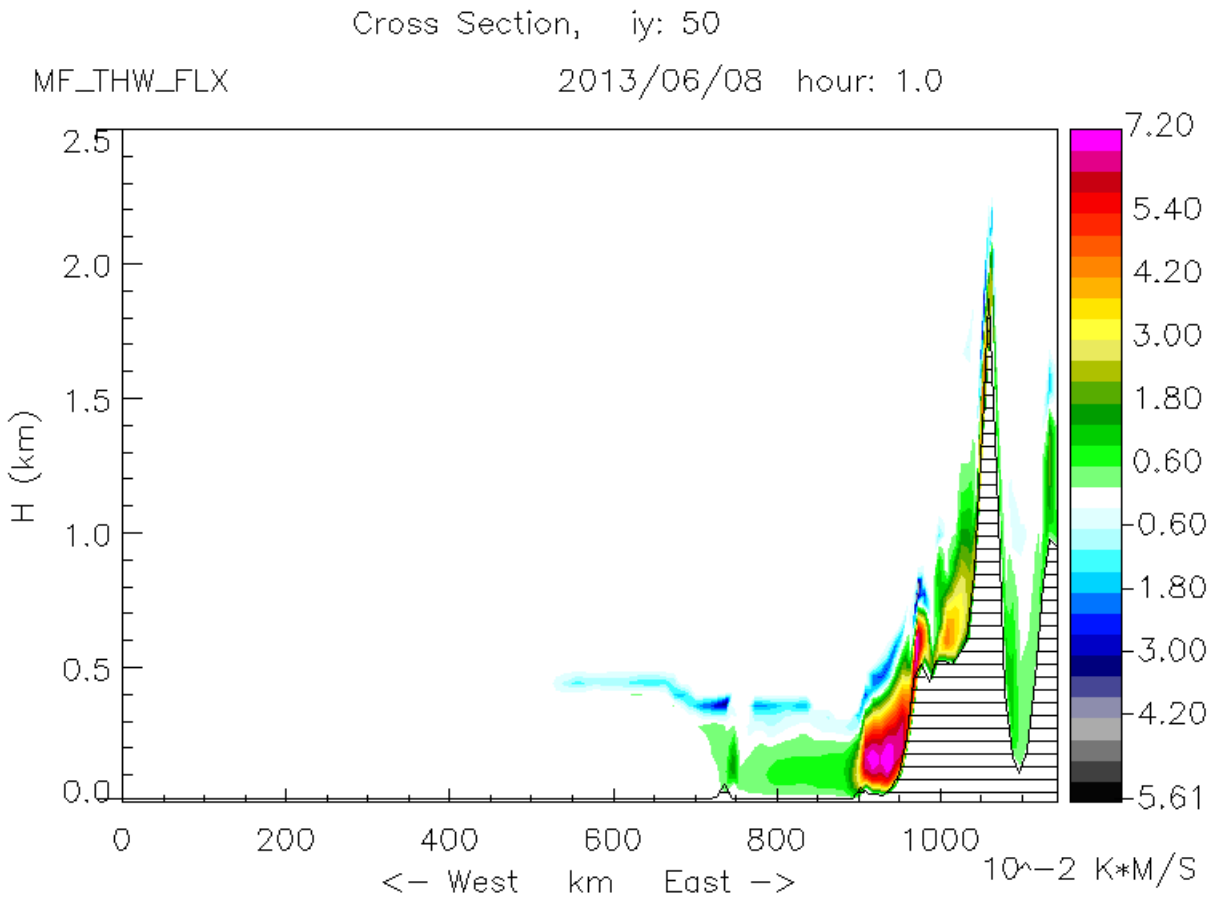
In terms of clouds over the airport, the simulation at a higher resolution do not have a significant impact: with the mass flux the height of the cloud base is also well represented, but the delay seems to be even bigger.

Mass flux

Mass flux: conservative potential temperature vertical flux

- More intense at the coastal zones
- Responsible for a more efficient mixing at low levels
- Accelerates low cloud / fog dissipation

W-E cross section of MF_THW_FLX



Conclusions

- preliminary results
- Meso-NH well simulate the formation and evolution of stratocumulus / fog clouds over South California coastal region (June Gloom) for several case studies (both at 3 and 9 km horizontal resolution)
  - The cloud base level is remarkably well simulated
  - However, the Model tends to underestimate fog, namely delaying its formation over coastal regions (including over the airport)
- The simulations with EDMF produce smaller cloud cover and cloud depth
  - increasing the mixing processes in the low levels.
- The height of the cloud base seems to be better represented in the simulation with EDMF.

Acknowledgements

The work was supported by:

- California Institute Of Technology / Jet Propulsion Laboratory - Earth Science Section 329

Jet Propulsion Laboratory
California Institute of Technology

ALENTEJO 2020 | PORTUGAL 2020 | UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

- COMPETE 2020 through the ICT project (UID / GEO / 04683/2013) with the reference POCI-01-0145-FEDER-007690 and by the ALOP (ALT20-03-0145-FEDER-000004) project.

Thanks