# Evaluation of Hydrological Cycle Predicted by MAP D-PHASE Models with GOP Observation

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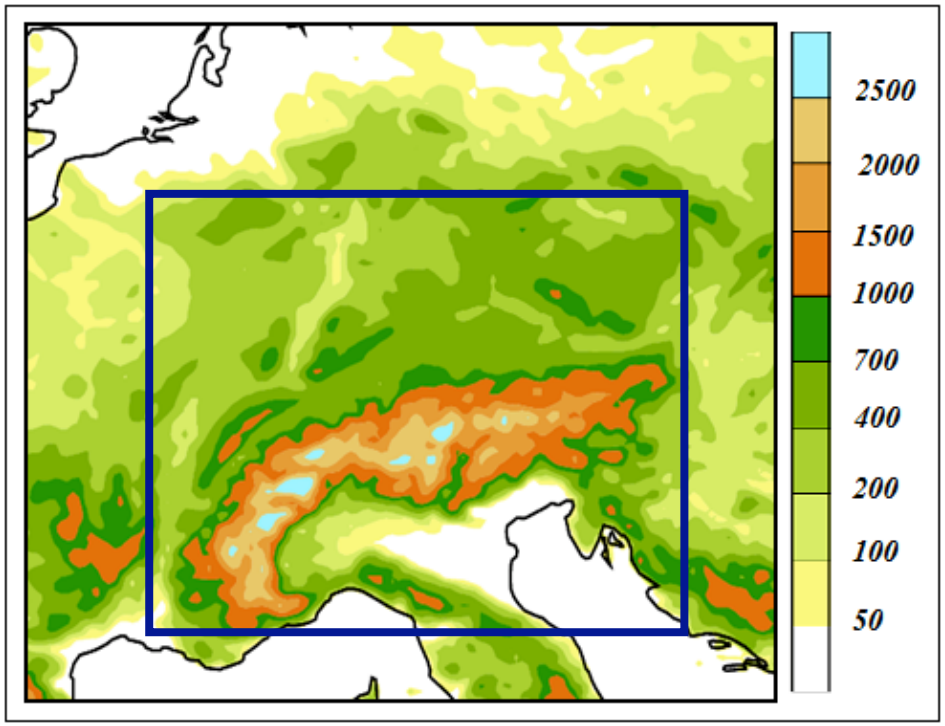
# D-Phase Overview

- Period: June – November 2007
- 6 ensemble prediction systems
- 7 convection permitting models
- 9 models with convection parameterization

**D-Phase Domain**



# Data Used

GPS:

Integrated Water Vapor - Temporal Resolution 15 minute

Ceilometer:

Low Cloud Cover - Temporal Resolution 10 minute

MSG:

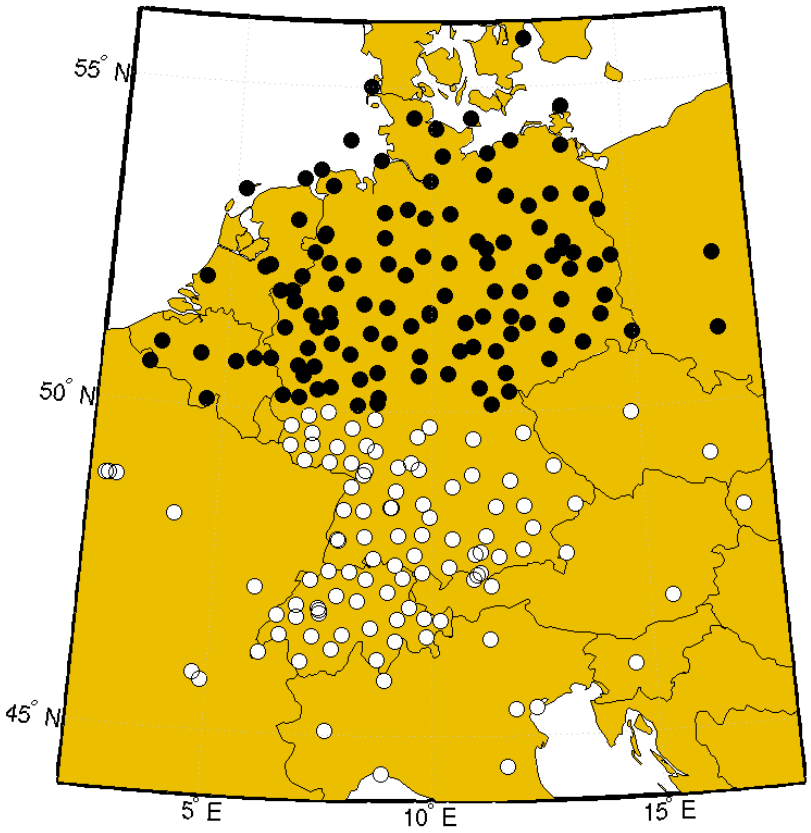
Cloud Occurrence Probability - Temporal Resolution 1 h

Cloud Top Pressure - Temporal Resolution 1 h
- Spatial Resolution: 5 km

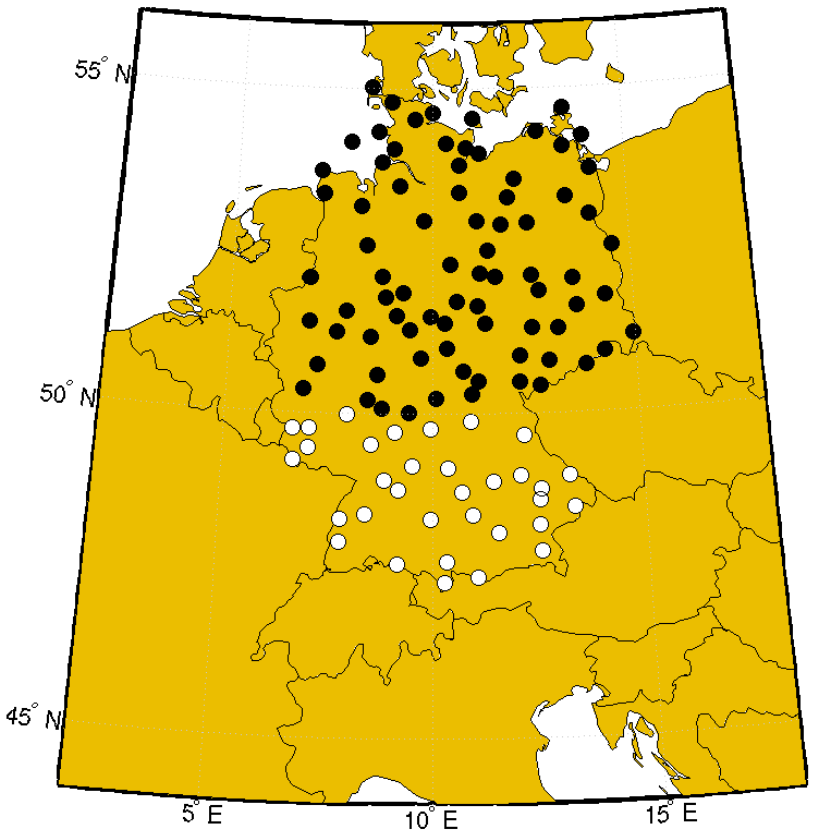
Precipitation Data: - Temporal Resolution 1 h
- Spatial Resolution: 7 km

(Matthias Zimmer,University of Mainz )

## Map of GPS Station

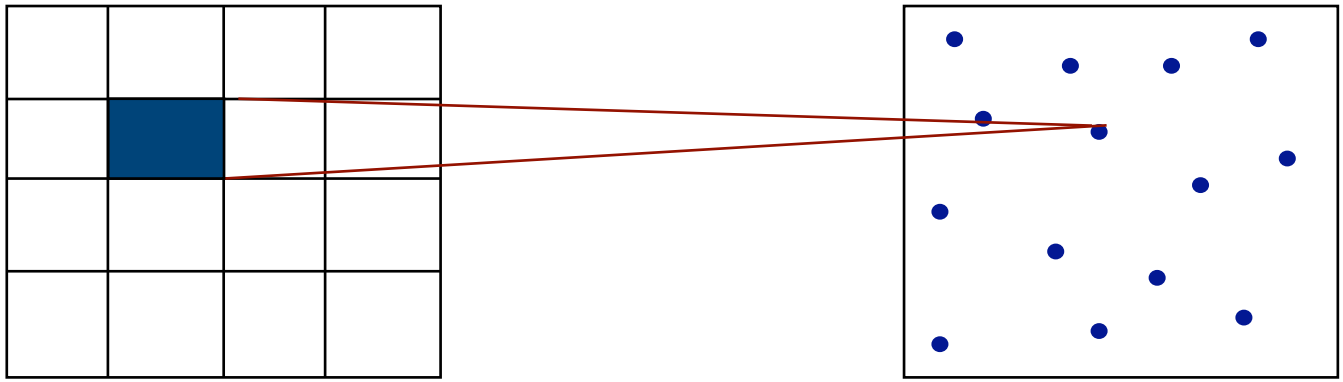



## Map of Ceilometer Station



# Diurnal Cycle of Mean IWV

# Association of surface stations to model grid points



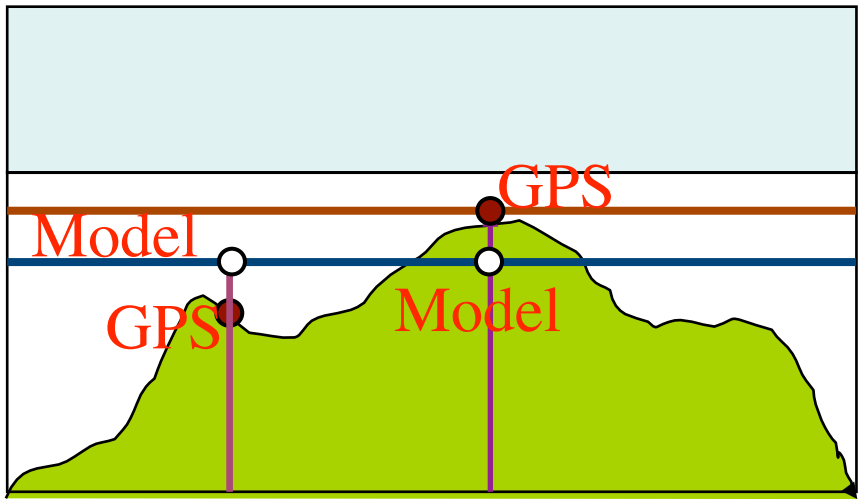
Model GPS Station

Optimization of horizontal distance and vertical Height difference

$$d_{opt} = d_{hor} + \left| d_{vert} \right| \cdot f_{ve} \qquad f_{ve} = 500 \longrightarrow$$ COSMO standard

Search Radius < 2 Grid

# Height correction in Integrated water vapor




Vertical Height difference < |200| m

$$\Delta IWV = \int_0^{\Delta h} q_v \rho dz$$

Station Height

Model Height

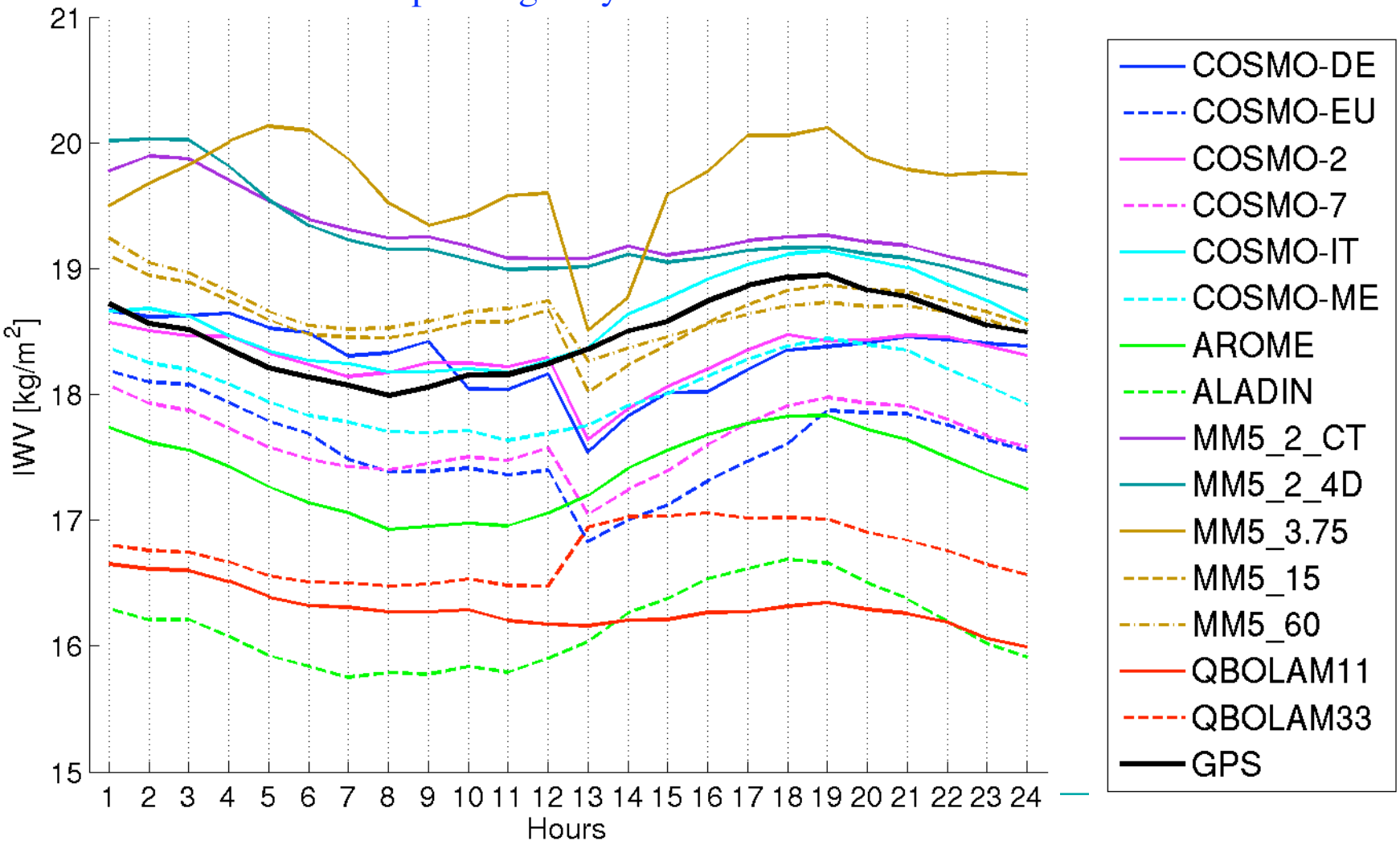
**Assumption** : Temperature and specific humidity are constant with height in model first level

# Mean IWV Diurnal Cycle (Recent Runs)

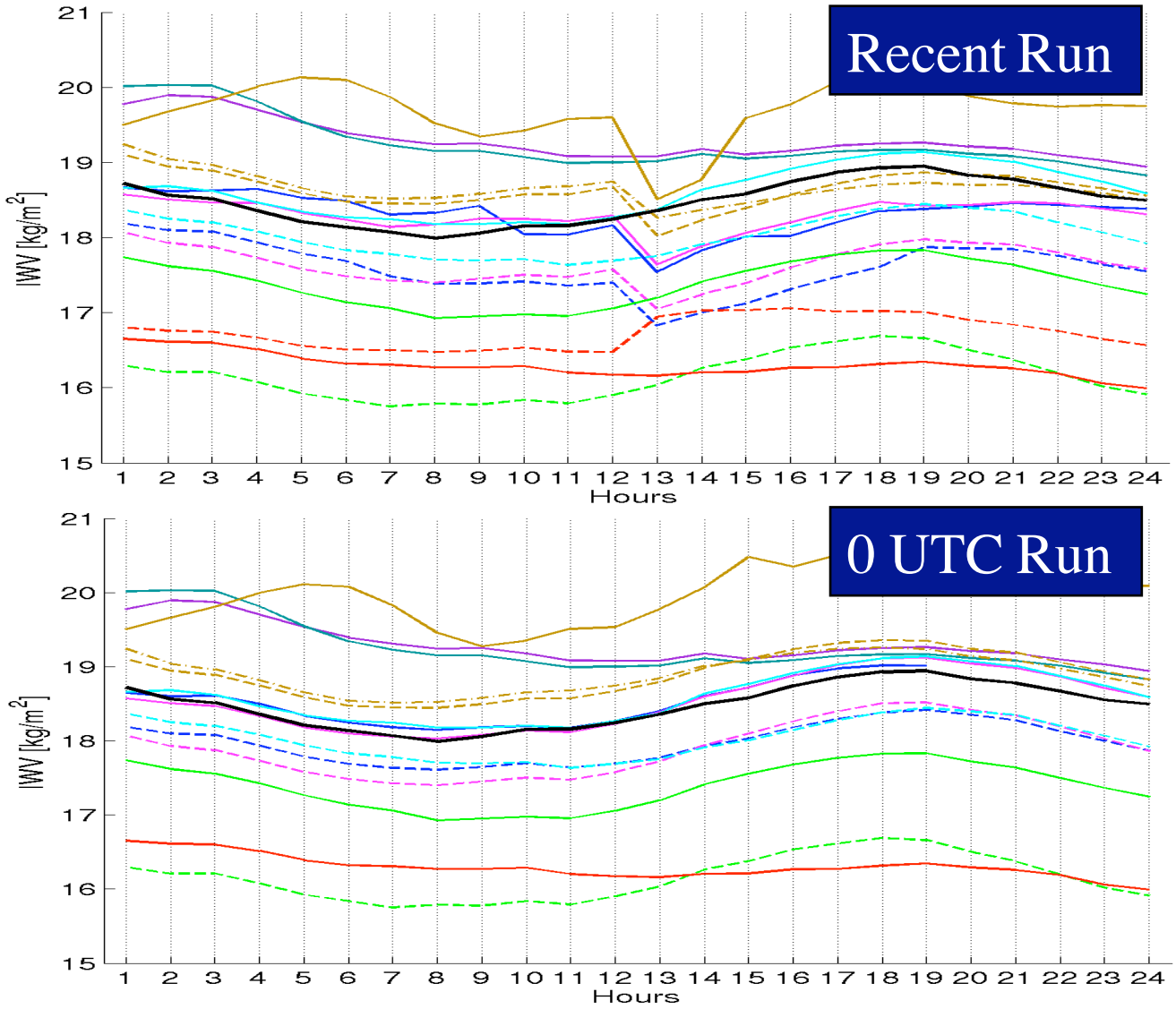
High Resolution model

Corresponding Low Resolution model

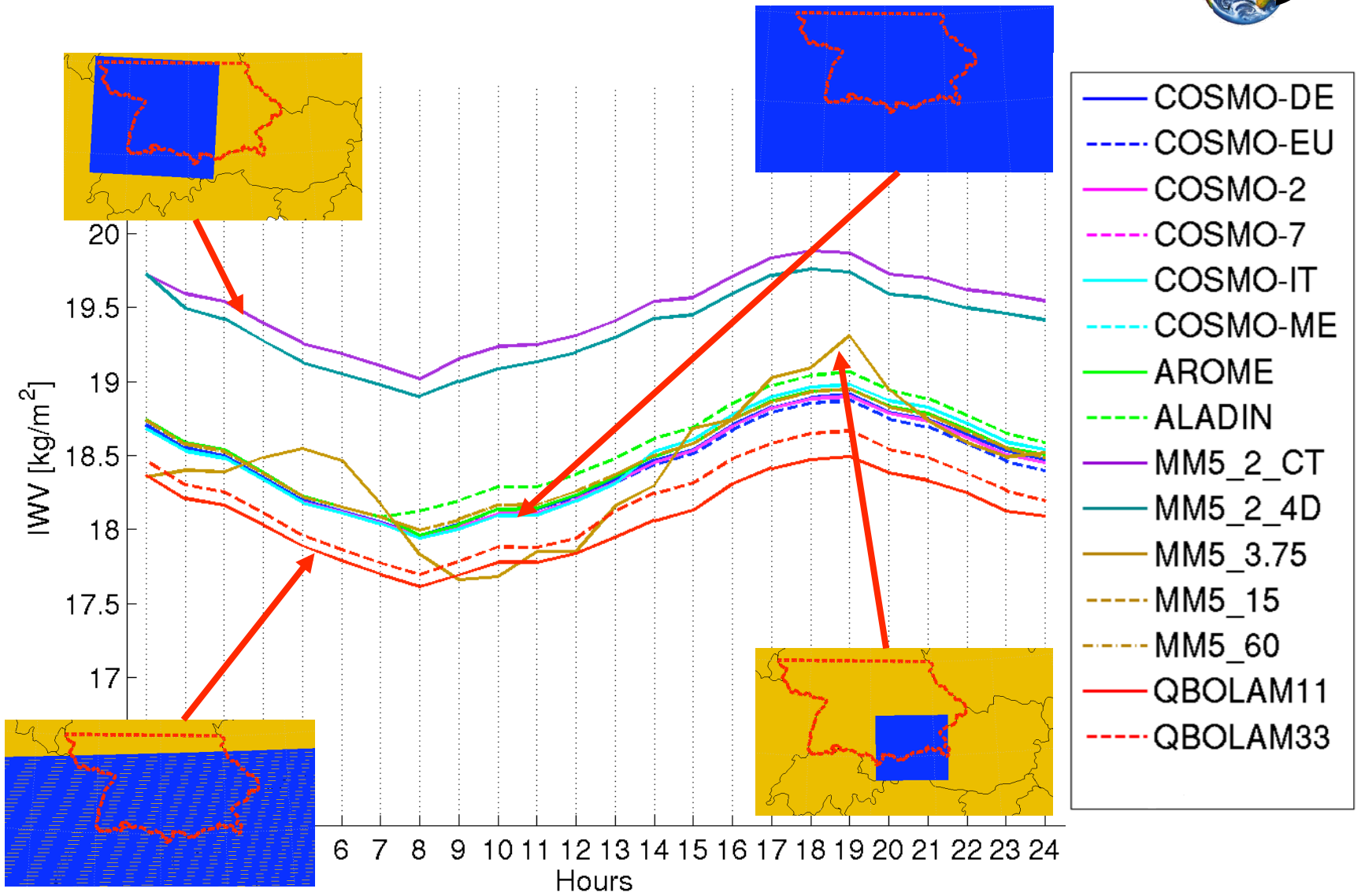
Corresponding Very Low Resolution model



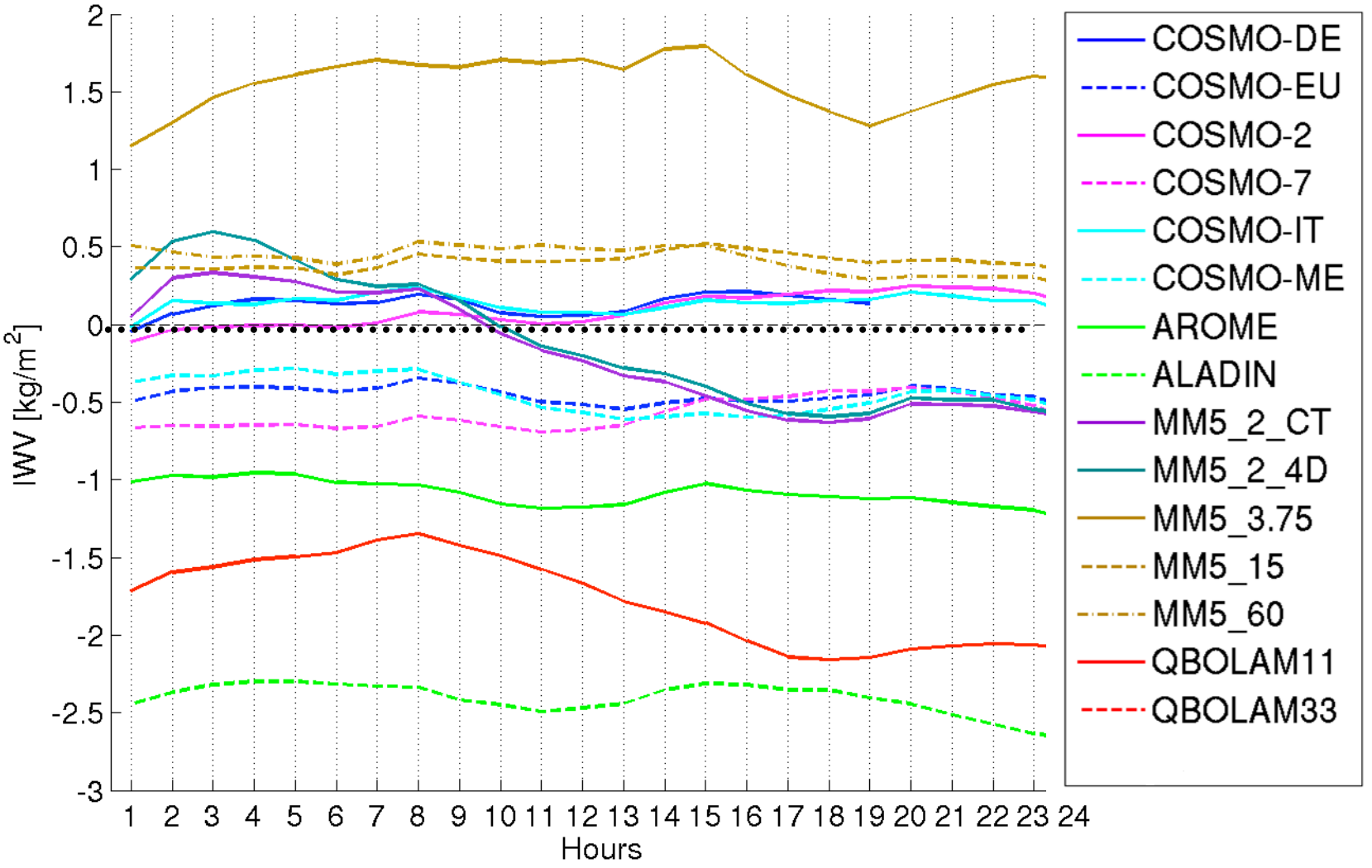
# Mean IWV Diurnal Cycle



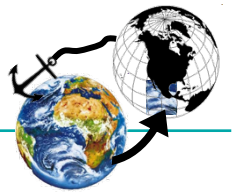
# Diurnal Cycle in GPS IWV (Correspond to Model)



# Diurnal Bias (Model – GPS) For 0 UTC Run



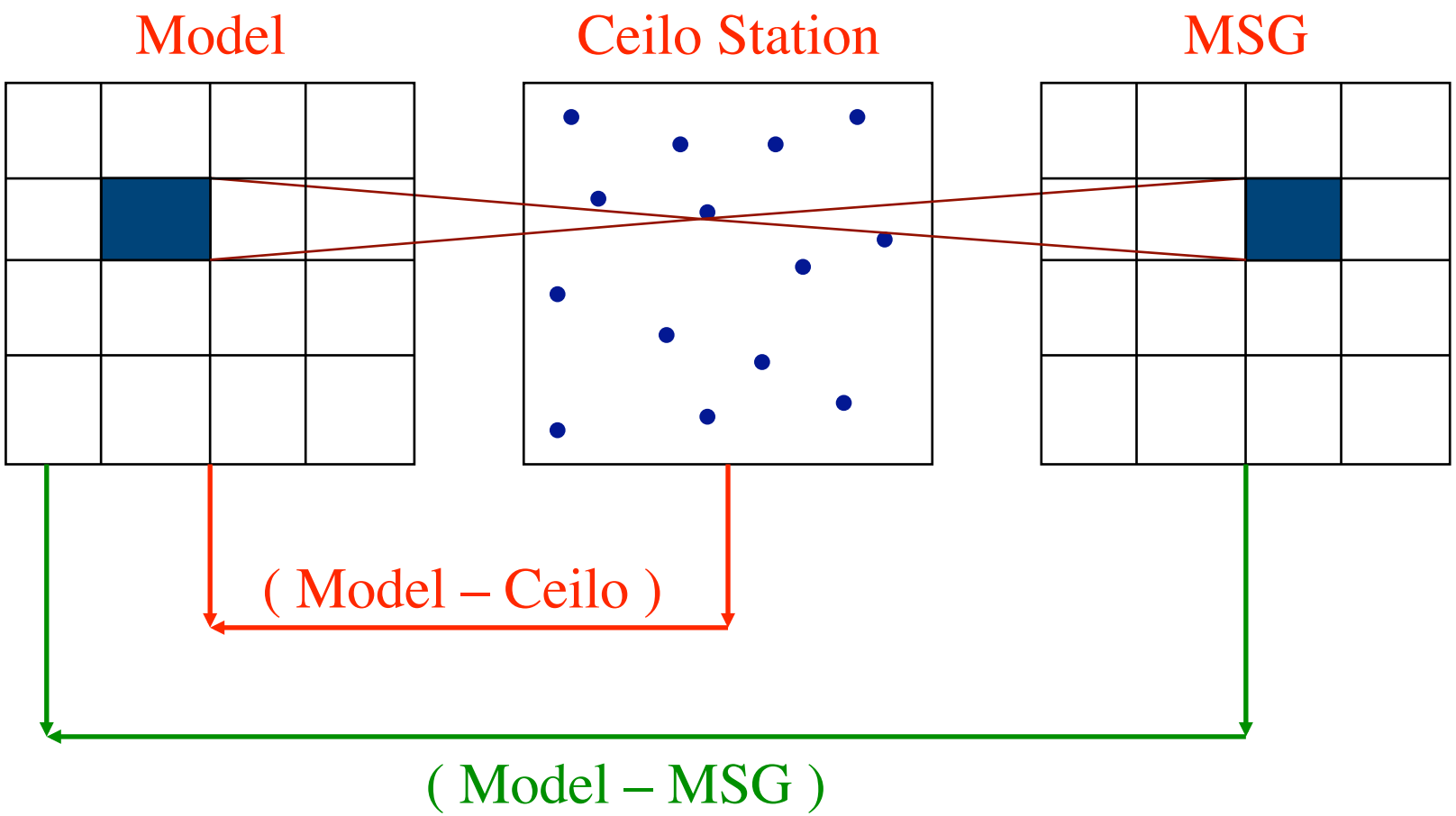
# In general:



- Observed diurnal cycle is well represented by most of the model.
- Models with 12 UTC run have jump effect in 12$^{th}$ hour.
- Nearly High resolution model have less bias compared to corresponding low resolution model.
- Models have fixed offset with observed IWV diurnal cycle.

# Diurnal Cycle of Cloud Cover

# Association of Ceilo station to models and MSG Grid



# High and Low cloud definition in Models & Obs

## Ceilometer Low Cloud Cover

low cloud cover = Ceilo cloud base (0 – 1200m) = 1

ceilo cloud base height > 1200 = 0

## MSG High Cloud Cover

High cloud cover = cloud occurrence probability (when

cloud top pressure (0 – 400 hPa)

High cloud cover > 50% = 1

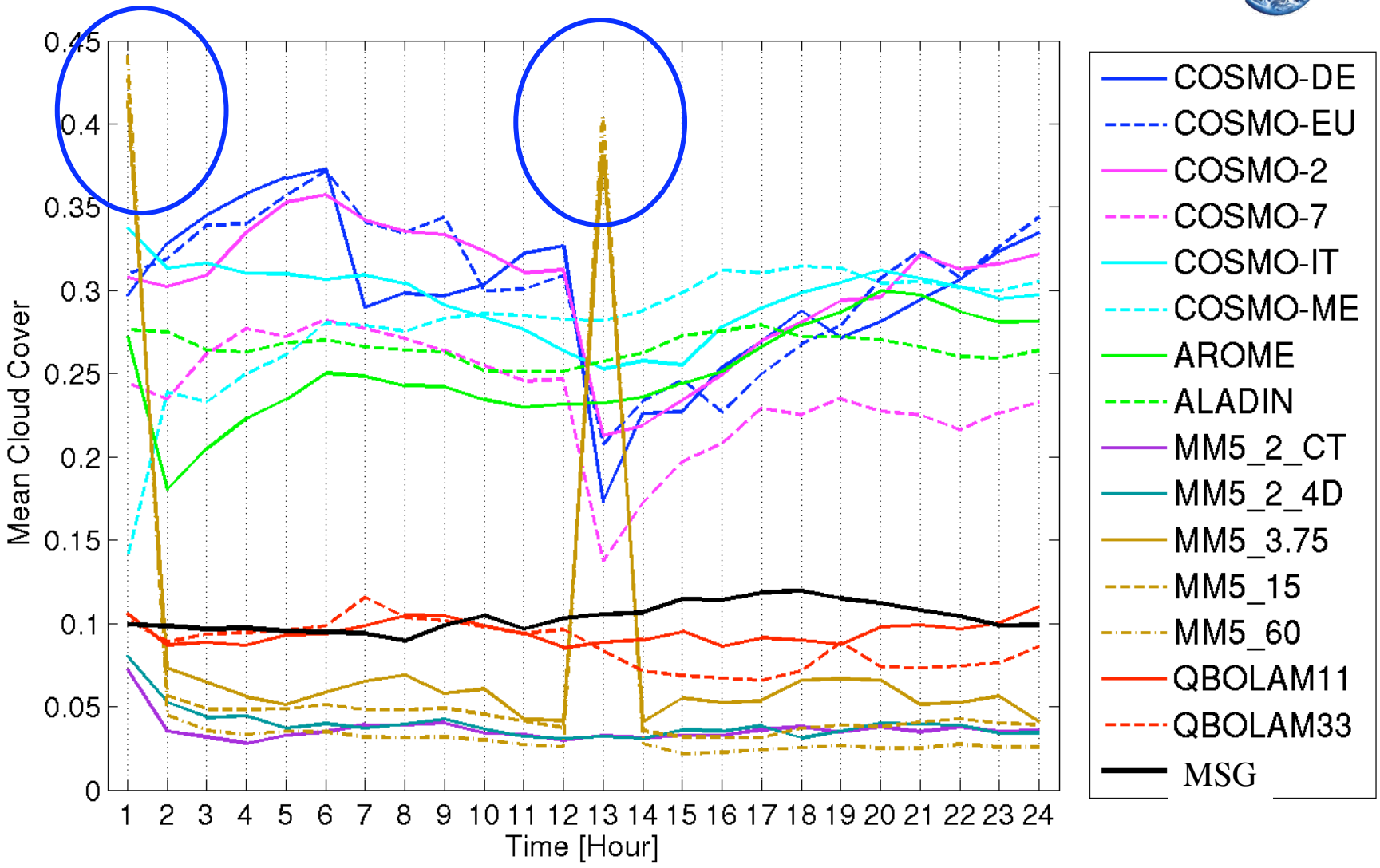
High cloud cover < 50% = 0

## Model Cloud Cover

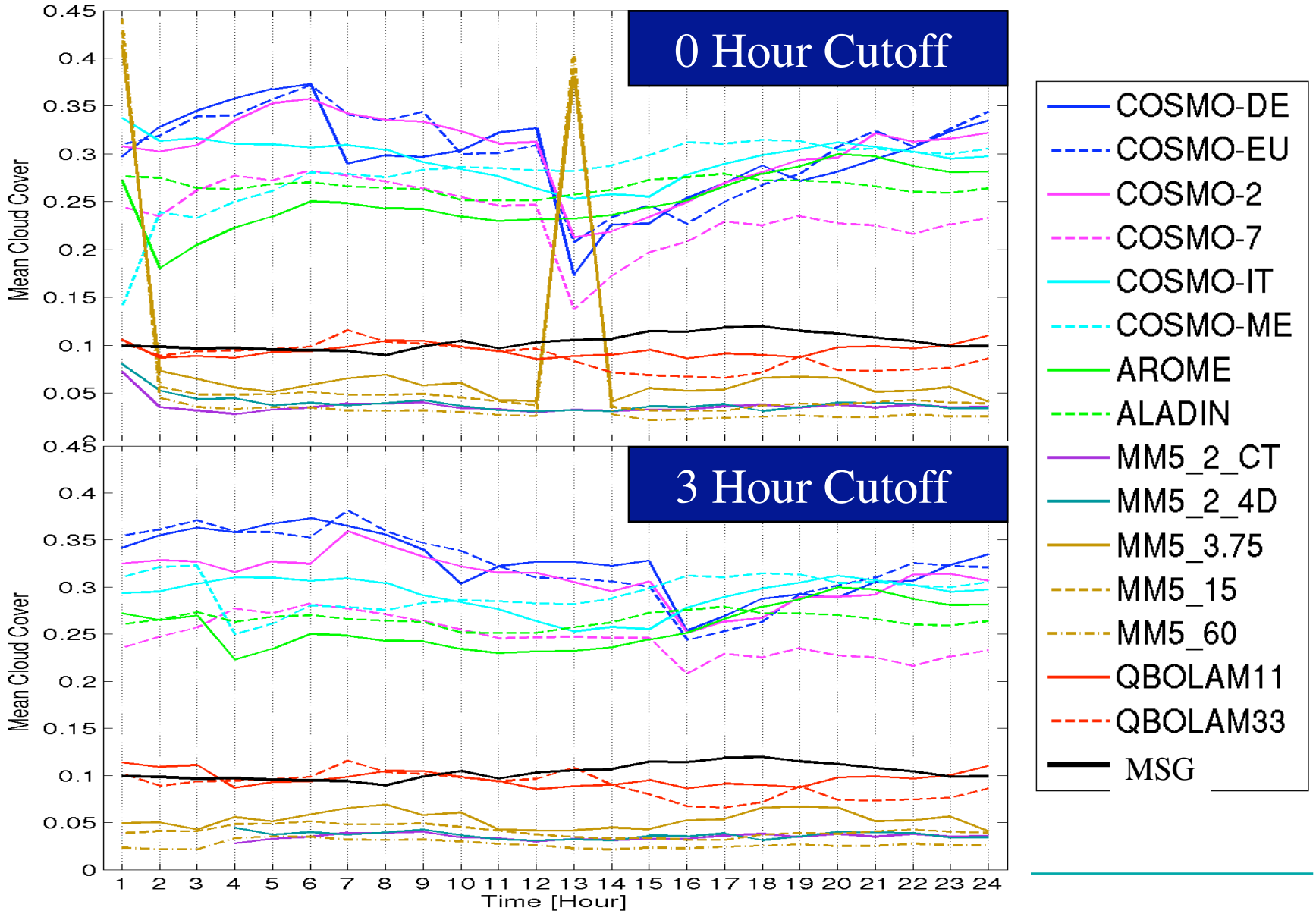
Model Cloud cover > 50% =1

Model cloud cover < 50% = 0

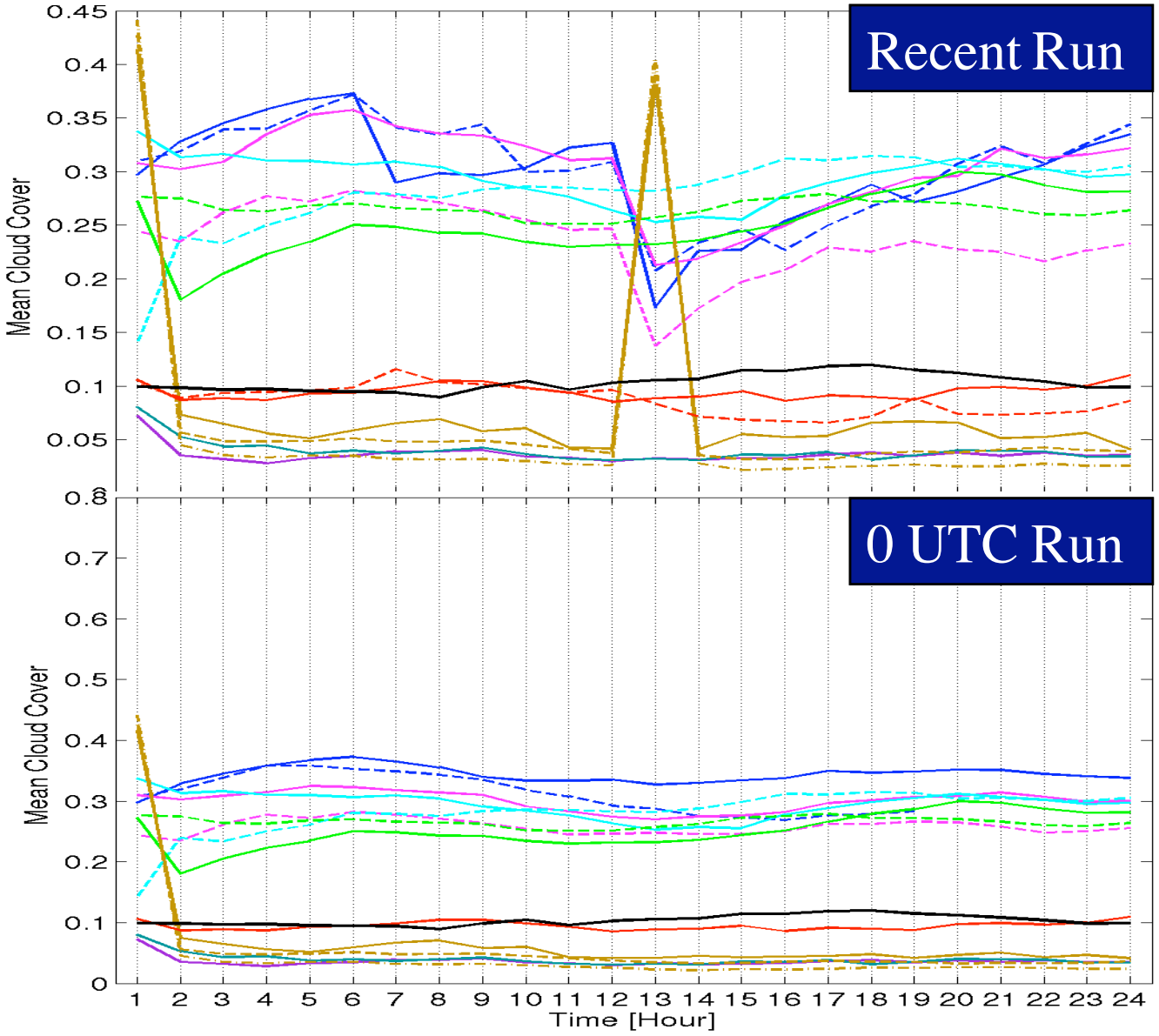
# Mean High Cloud Cover Diurnal Cycle (Recent Runs)



# Mean High Cloud Cover Diurnal Cycle

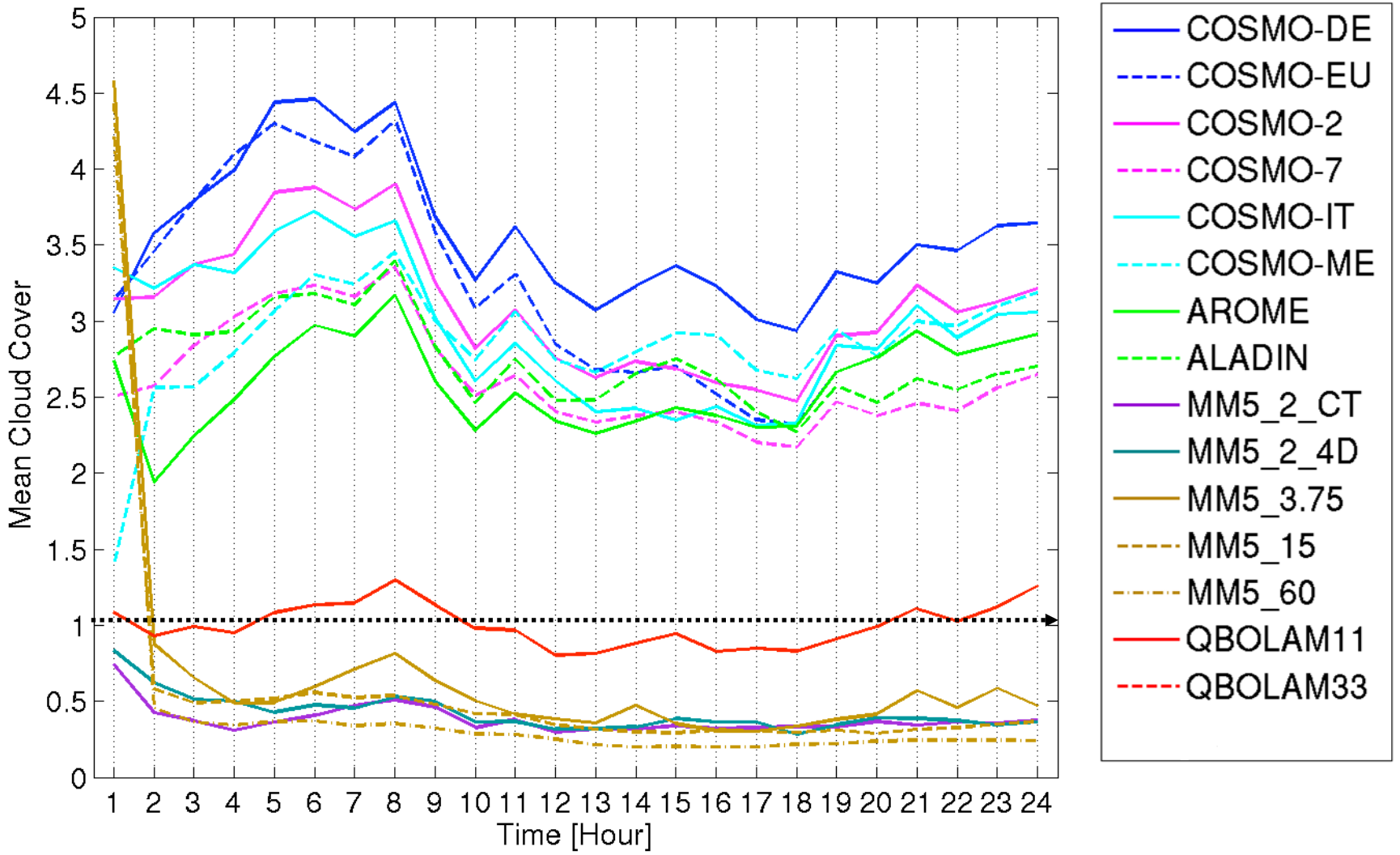


# Mean High Cloud Cover Diurnal Cycle

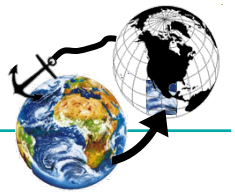



- COSMO-DE
- COSMO-EU
- COSMO-2
- COSMO-7
- COSMO-IT
- COSMO-ME
- AROME
- ALADIN
- MM5_2_CT
- MM5_2_4D
- MM5_3.75
- MM5_15
- MM5_60
- QBOLAM11
- QBOLAM33
- MSG

# Diurnal FBIAS (Model – MSG) High Cloud 0 UTC Run

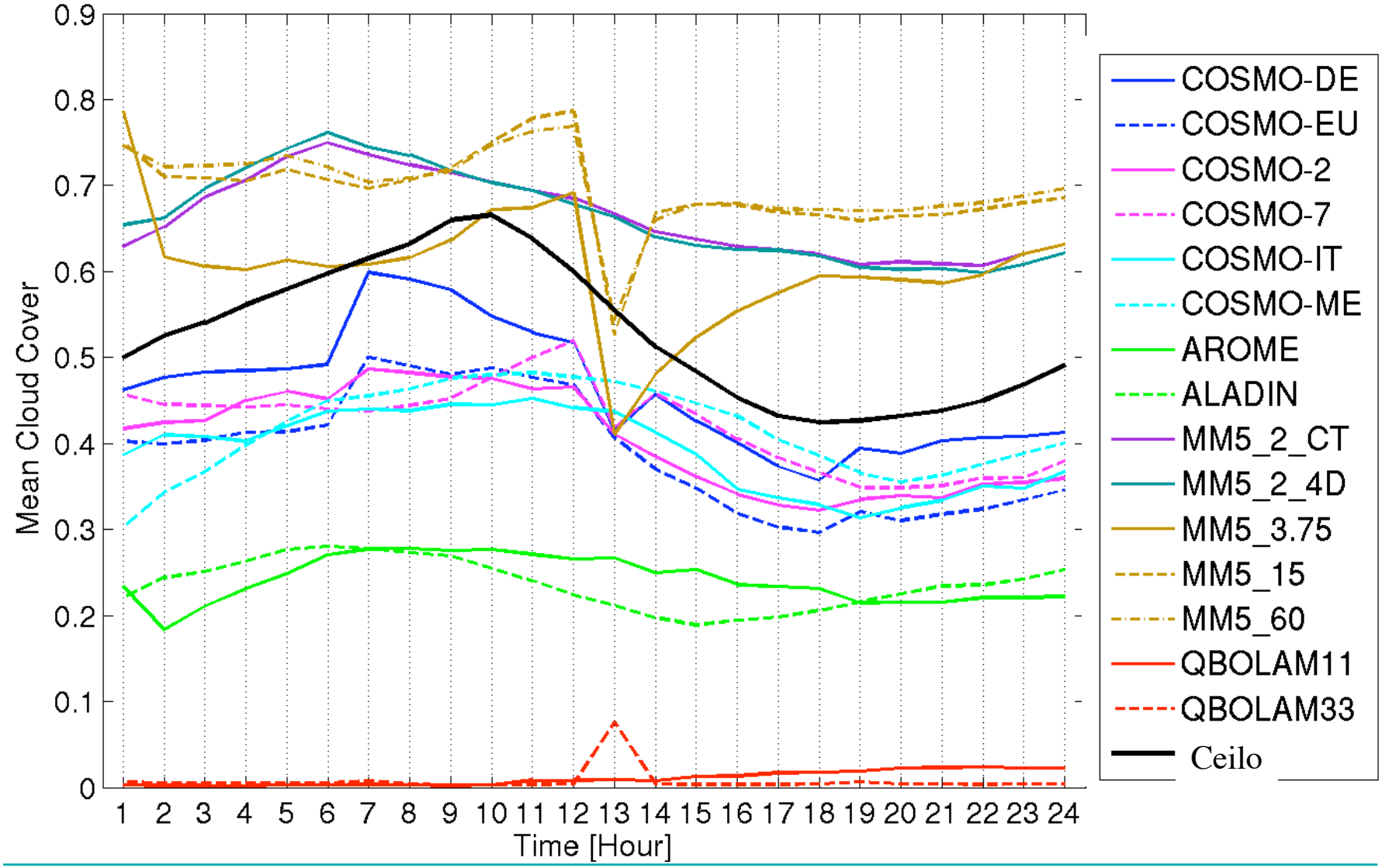


# In general:

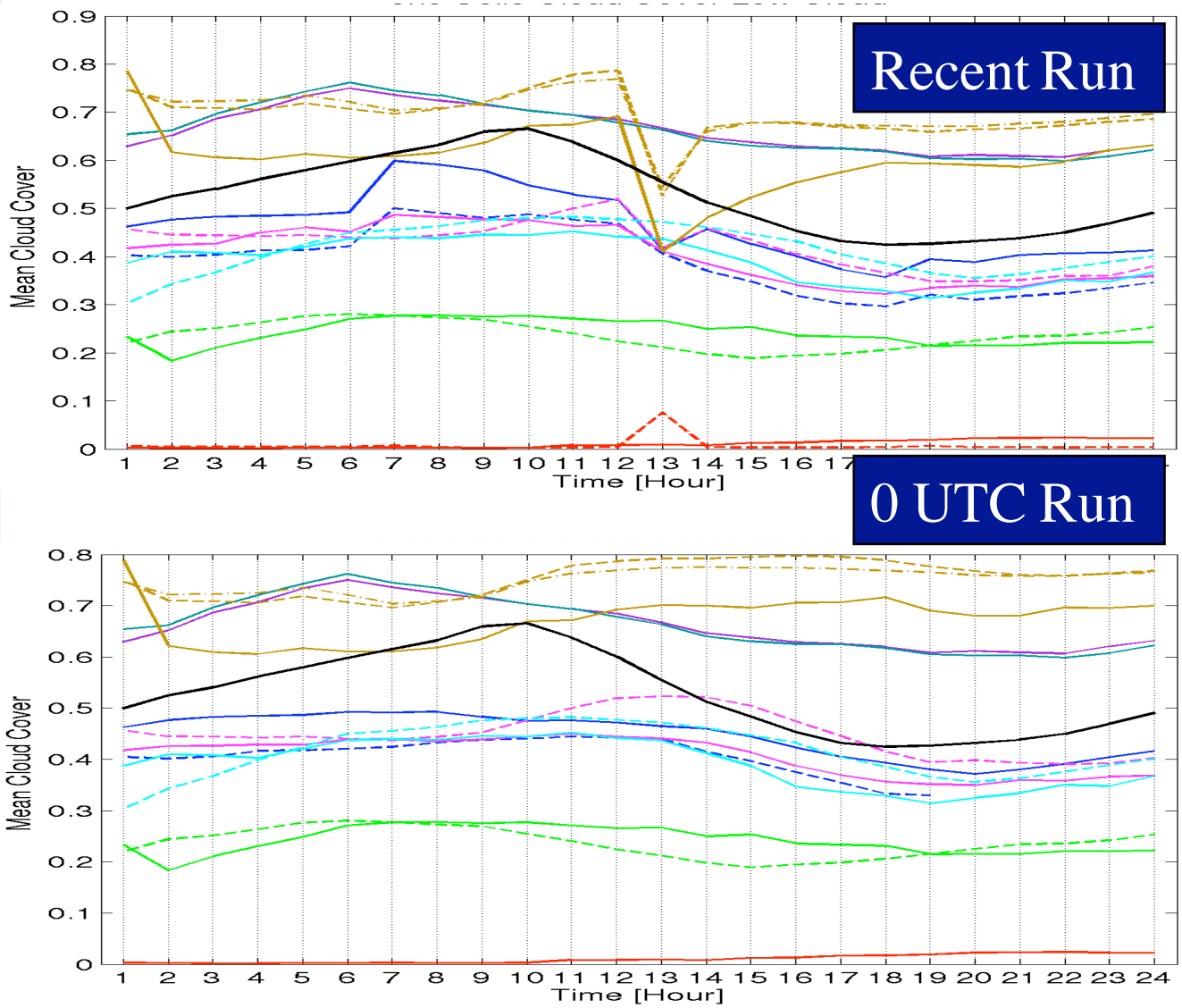


- No significant diurnal cycle in High cloud cover in both MSG and Model
- COSMO models with 12 UTC run have jump effect in 12$^{th}$ hour.
- MM5 models are underestimating while, while Qbolam models are quit accurate, other models are overestimating the high cloud cover.

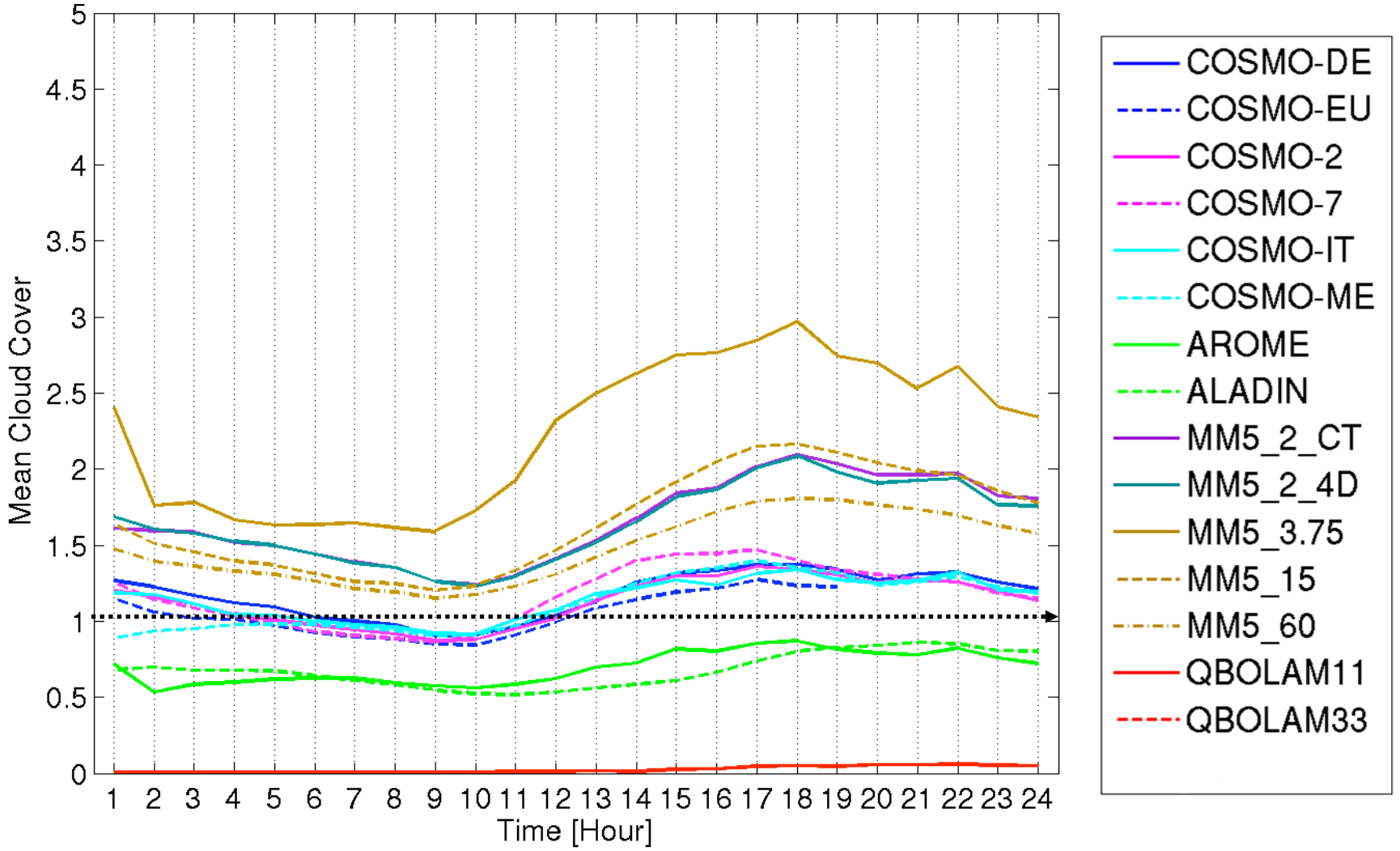
# Mean Low Cloud Cover Diurnal Cycle (Recent Runs)



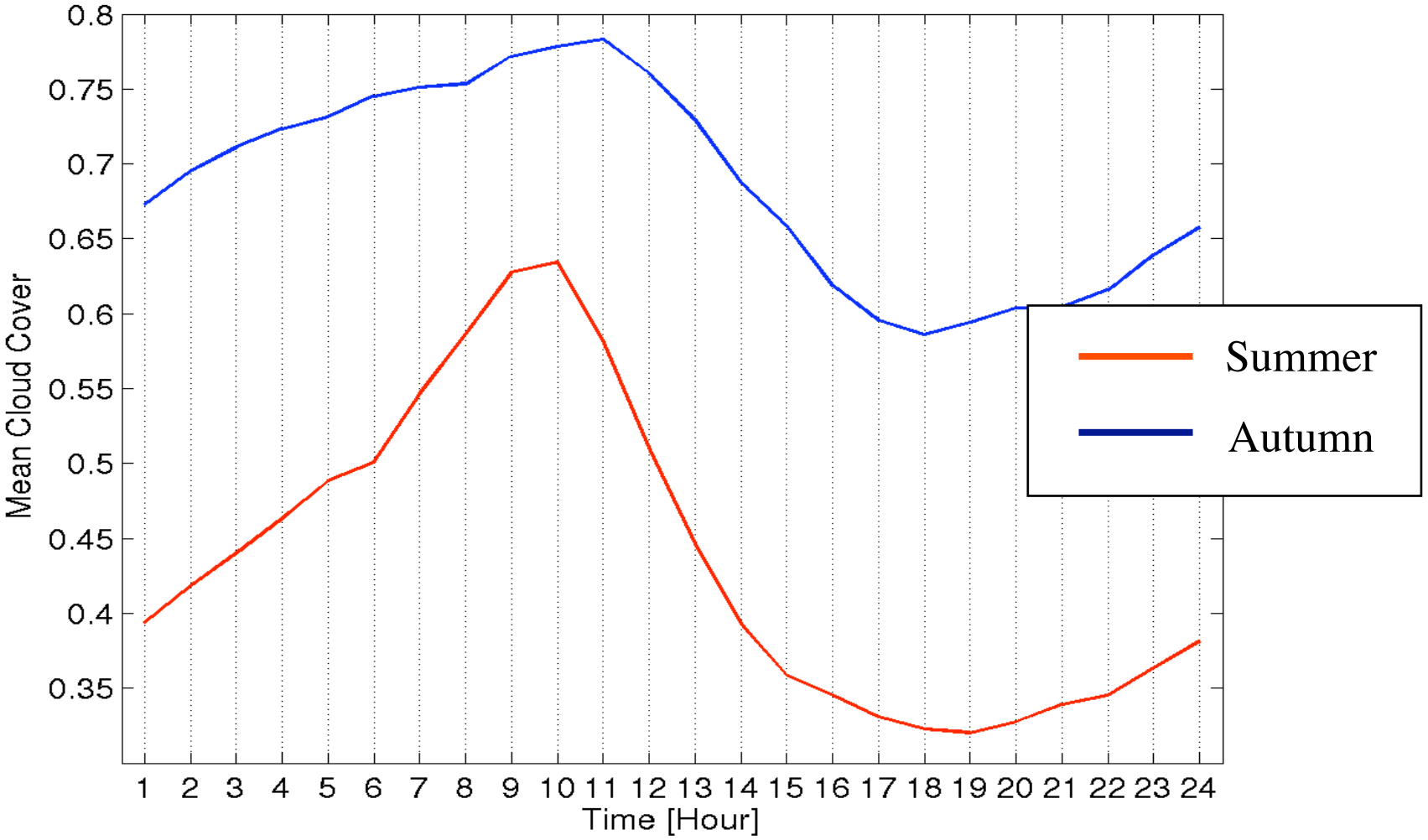
# Mean Low Cloud Cover Diurnal Cycle



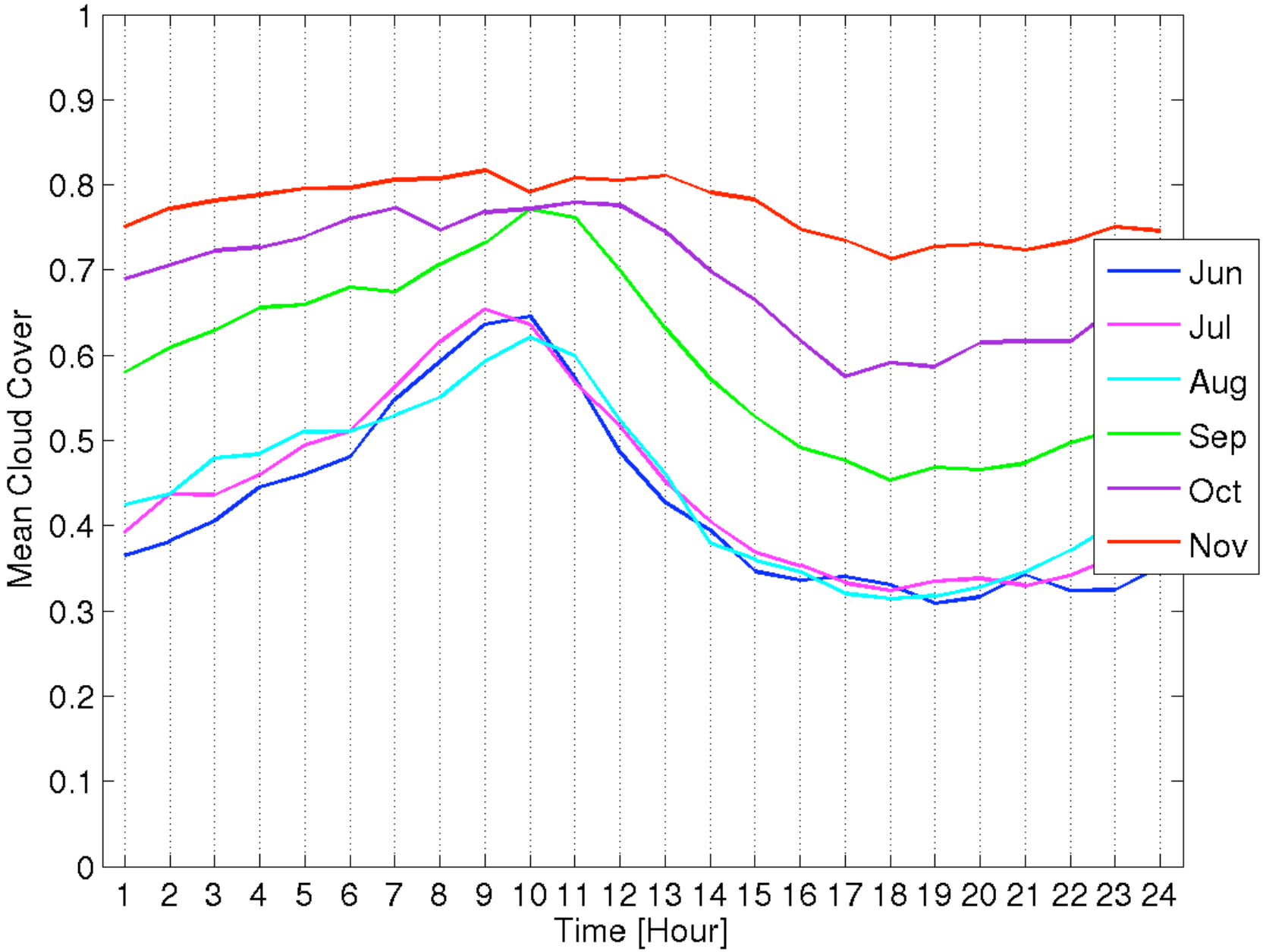
# Diurnal FBIAS (Model – Ceilo) Low Cloud 0 UTC Run



# Ceilometer Low cloud cover Diurnal cycle



# Ceilometer Low cloud cover Diurnal cycle



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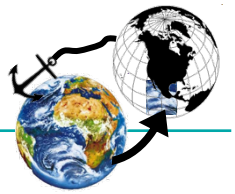


- Observed diurnal cycle in low cloud well repented by Models.

- All model which have run on 12 UTC have jump effect in $12^{th}$ hour.

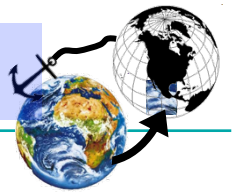
- Model predicted diurnal cycle have phase shift of nearly 4 hour to observation.

- All COSMO models have very less bias, while MM5 are overestimating and Arome, Aladin and Qbolam are underestimating.

# SAL Precipitation Verification Method

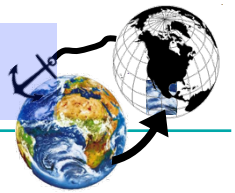
(Matthias Zimmer,University of Mainz )

# SAL



- novel quality measure (Wernli et al. 2008 MWR)
- pre-defined region, e.g. a Sub domains
- identification of rain objects
  - → feature-based
  - → no explicit matching required
- three independent components
  - → Structure (S), Amplitude (A), Location (L)

# SAL – Definition of Components



$A = (D(R_{mod}) - D(R_{obs})) / 0.5*(D(R_{mod}) + D(R_{obs}))$

D(...) denotes the area-mean value (e.g. Sub Domain)
normalized amplitude error in considered area
$A \in [-2, ..., 0, ..., +2]$

$L = |r(R_{mod}) - r(R_{obs})| / dist_{max}$ + measure of distance of objects to r(...)

r(...) denotes the centre of mass of the precipitation field in the area
normalized location error in considered area
$L \in [0, ..., 2]$

$S = (V(R_{mod}*) - V(R_{obs}*)) / 0.5*(V(R_{mod}*) + V(R_{obs}*))$

V(...) denotes the weighted volume average of all scaled precipitation objects in considered area
normalized structure error in considered area
$S \in [-2, ..., 0, ..., +2]$

- **S Component (Structure)** → **size and shape**

  **too small/peaked perfect too large/flat**
  **-2 … 0 … 2**

- **A Component (Amplitude)** → **amount**

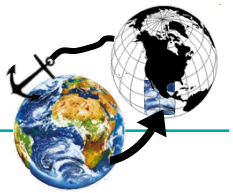
  **too little perfect too much**
  **-2 … 0 … 2**

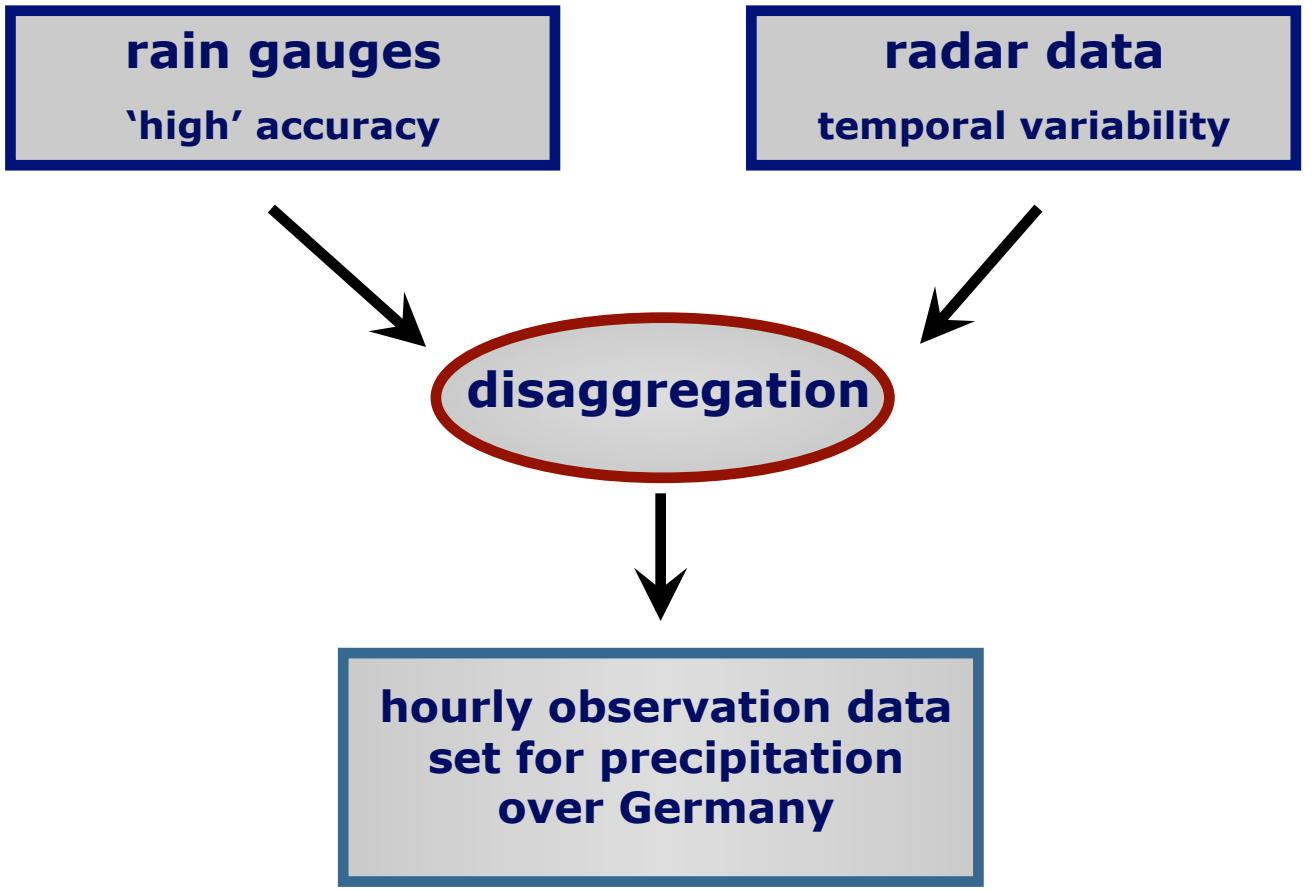
- **L Component (Location)** → **position**

  **perfect far away**
  **0 … 2**

- **perfect score: S = A = L = 0**

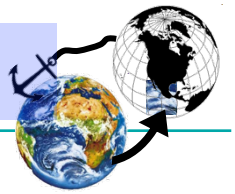
# Obs Hourly Precipitation Data over Germany






Paulat et al., 2008

# Analysis



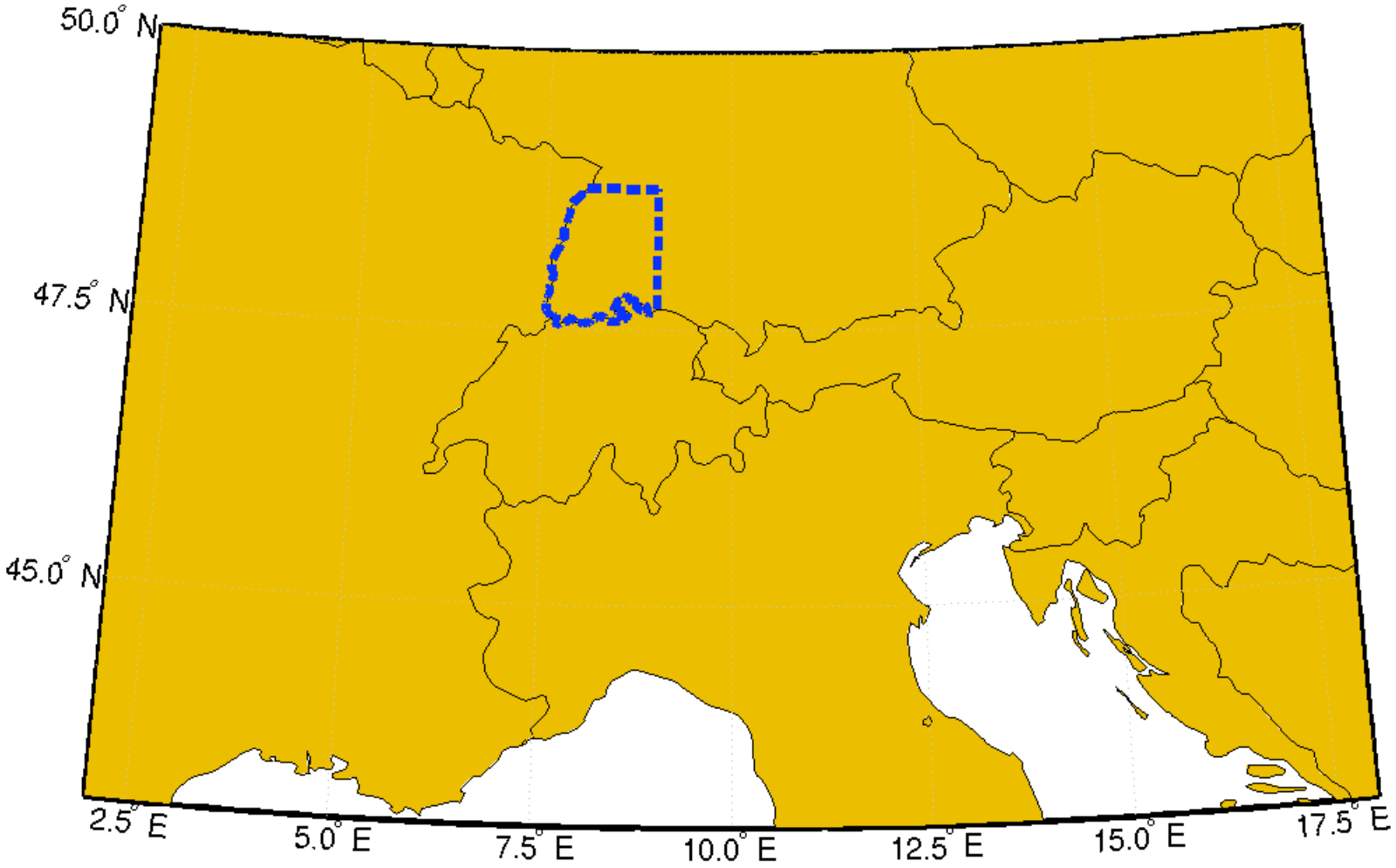
- Model Forecast:

  Used 00 UTC runs
  accumulation periods 3h
  SAL Analysis for 3h, 6h, 9h, 12h, 15h, 18h, 21h

- horizontal grid:

  observation and forecasts were transformed onto a grid of 7 km

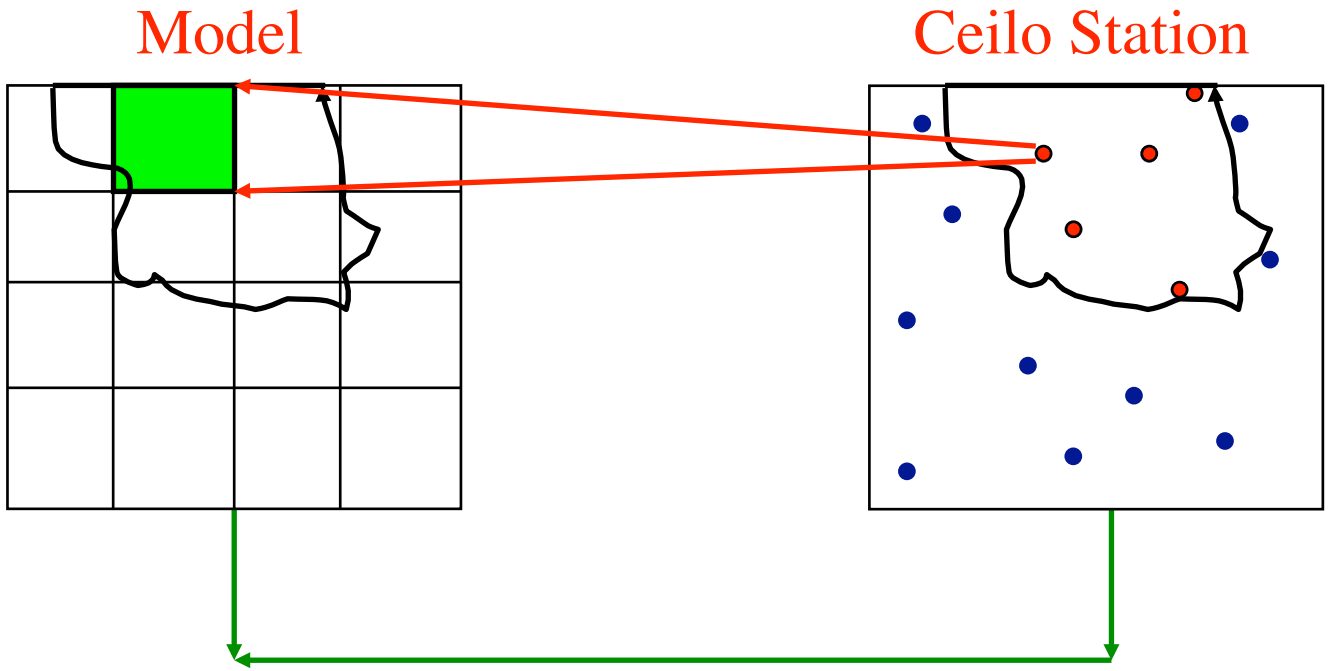
# Domain GSWS



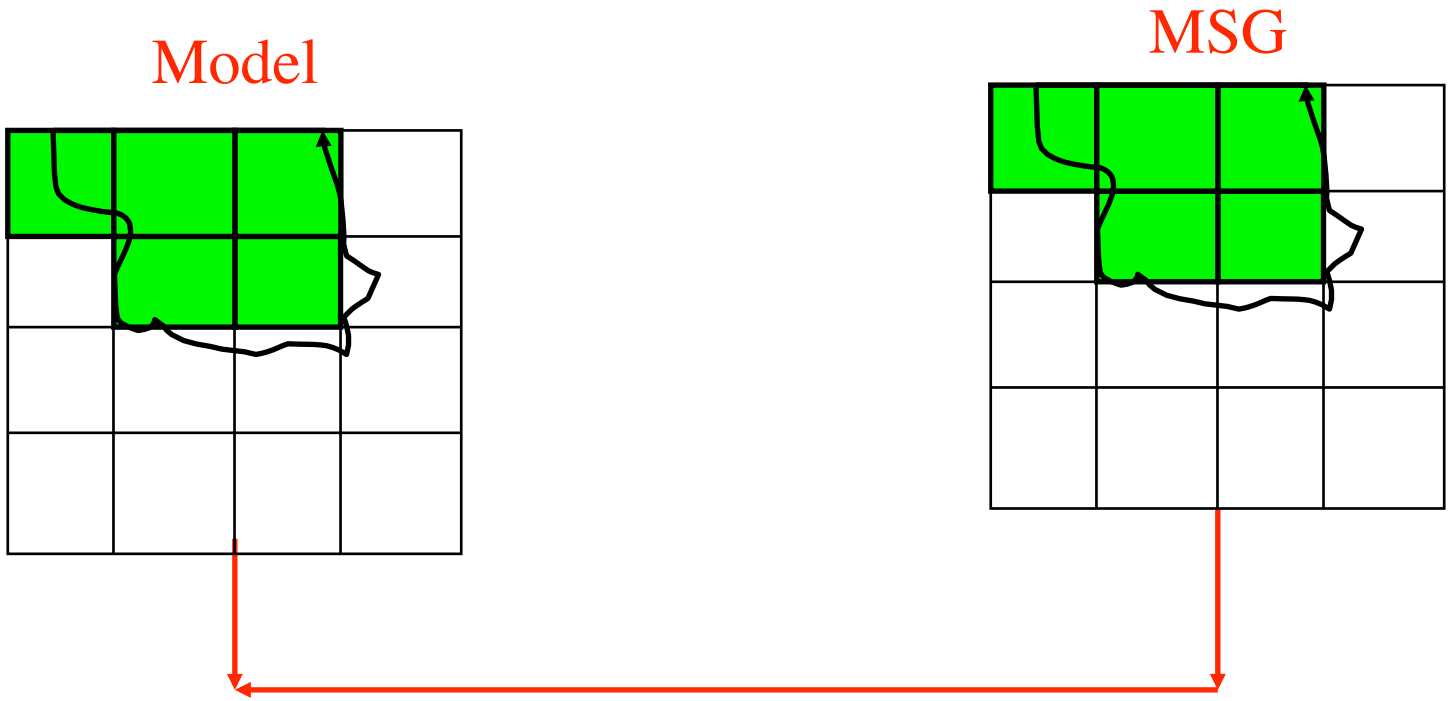

**No. Ceilometer: 3**

**No. GPS: 6**

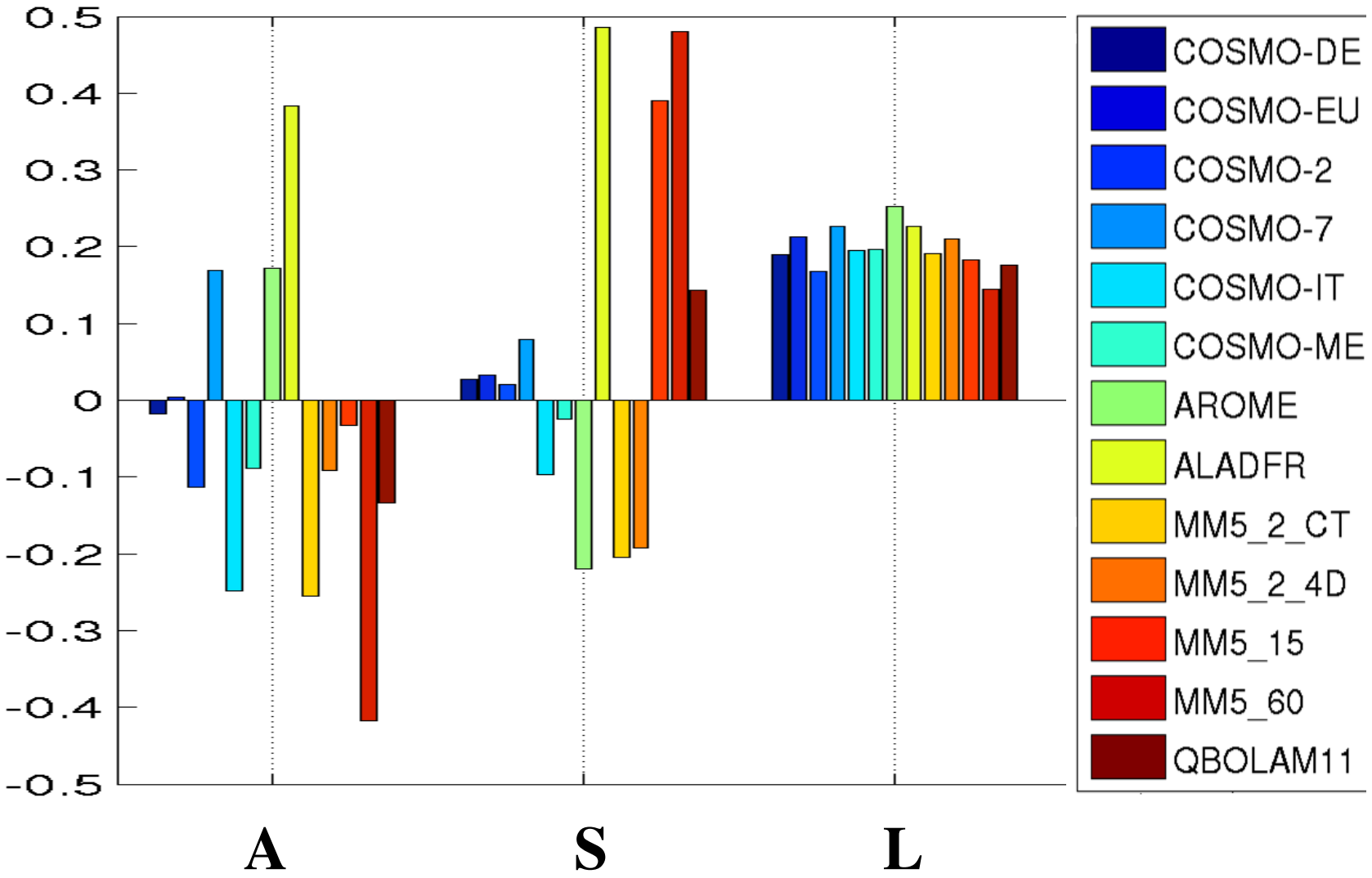
# Association of Ceilo station to models Grid in Sub Domain



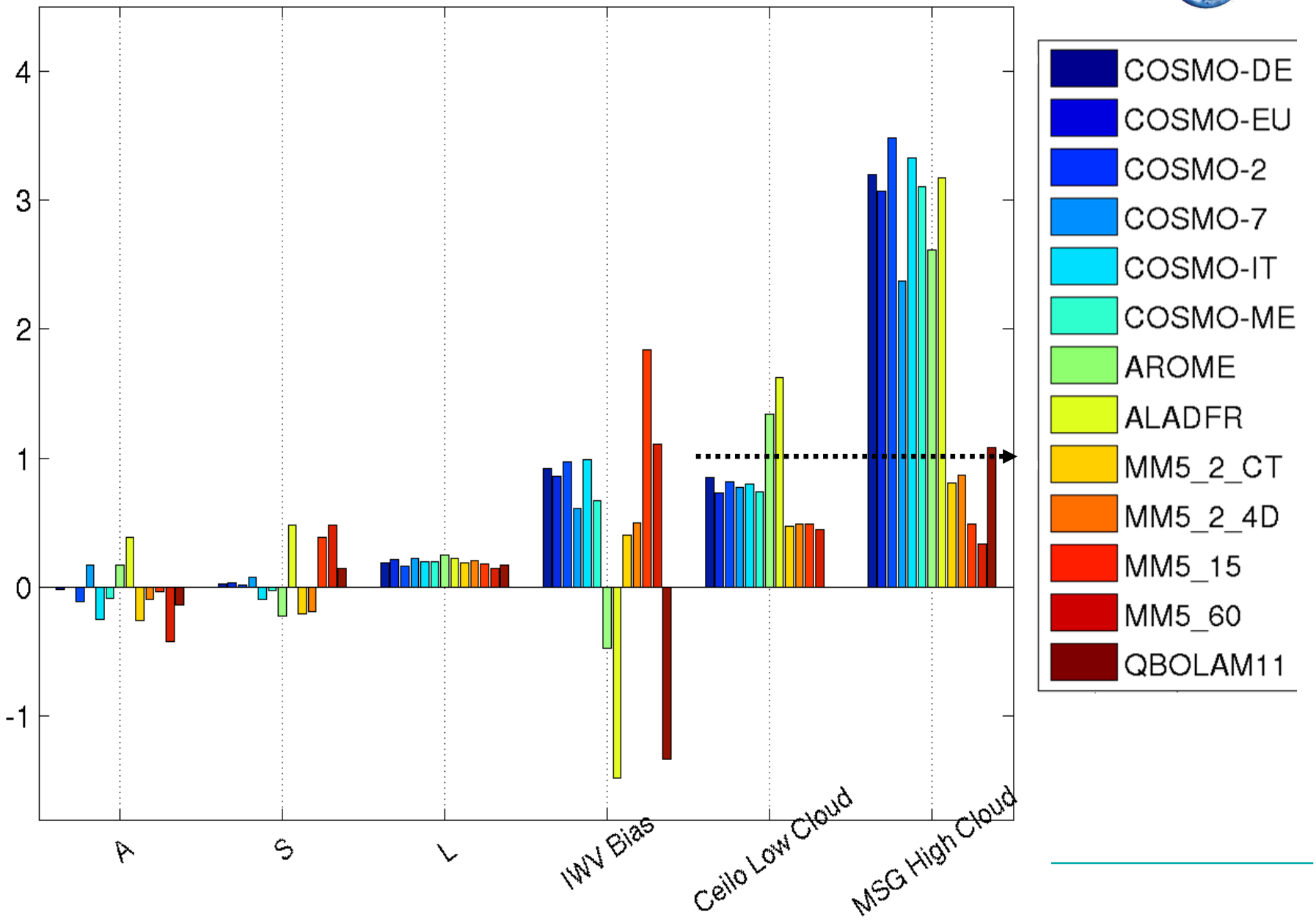
# MSG and Models Grid in Sub Domian



# SAL Component for GSWS Domain



# GSWS Domain Average Analysis



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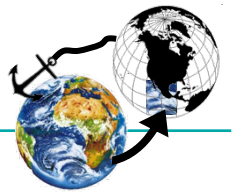


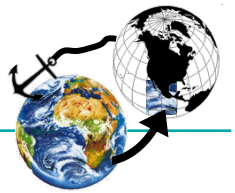
- Cosmo-DE, Cosmo-EU & MM5_15 predicted precipitation quit well.
- MM5_2_4d shows the improvement in predication over MM5_2_ct.
- Arome, MM5_2_4d and MM5_2_ct have lowest bias in IWV.
- COSMO underestimating low cloud cover and over estimating high cloud cover.

# Conclusions

## Diurnal Cycle (D-Phase Domain)

- Diurnal cycle in IWV and low cloud cover are well represented by most of the model.
- Model having 12 UTC run have jump effect in 12th hour, in IWV, low cloud cover and high cloud cover, except MM5 in High cloud cover.
- Model predicted diurnal cycle in low cloud cover have phase shift of 4 hour to observation.
- Model which are underestimating or slightly overestimating low cloud cover, are overestimating high cloud cover and vice versa

# Conclusions

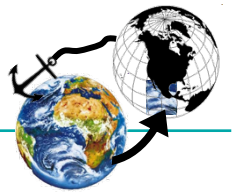


## Sub Domain Analysis ( GSWS Domain)

- Cosmo-DE, COSMO-EU & MM5_15 predicted precipitation quit well.

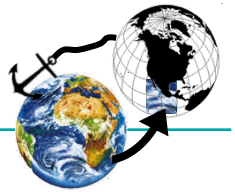
- MM5_2_4d with GPS data assimilation have improvement in predication over MM5_2_ct.

# What's Next



- Aggregate in details verification results to sub-domains. Start searching for error structures

- Start with D-PHASE Ensemble systems



# Thank You