Evaluation of the Atmospheric Water Cycle Predicted by MAP D-PHASE Models using GOP Observations

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Research Questions

GOP observe these key variables of the atmospheric water cycle

- How accurate can these key variables be forecasted by today's mesoscale models?
- Is the forecasting performance of convection permitting high resolution models superior?
- Are there clusters of models revealing the same kind of model errors?
- What is the most important factor (e.g. boundary conditions, model formulation or resolution), affecting the forecast performance?

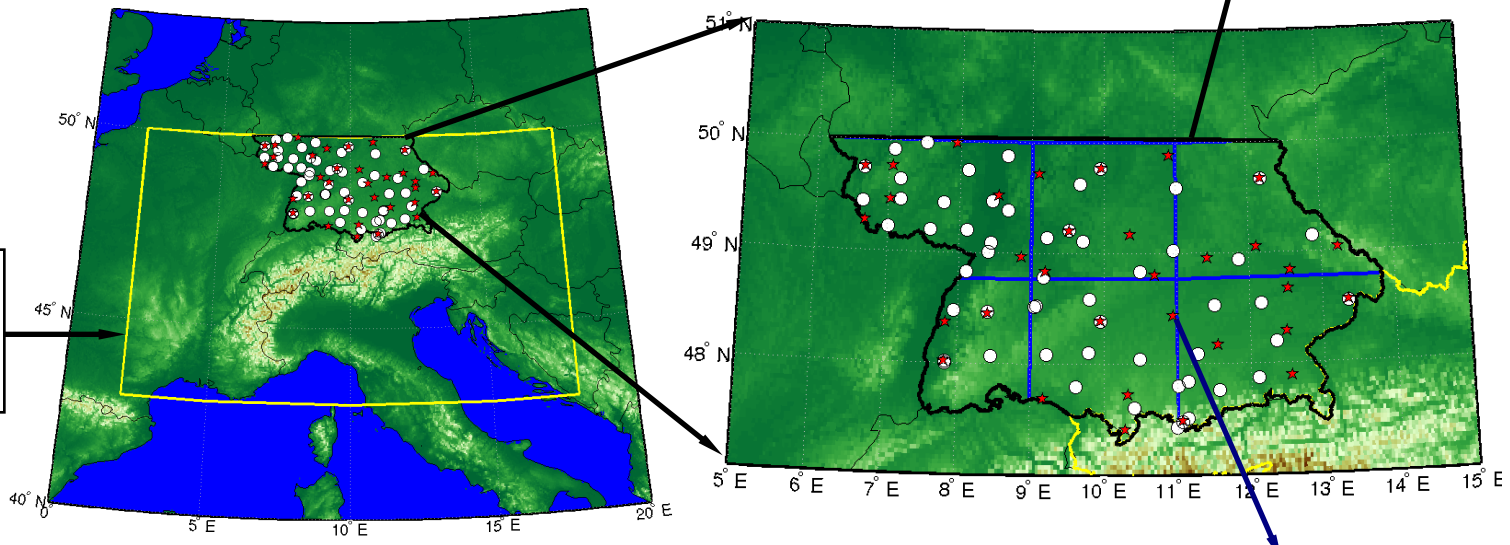
D-PHASE Overview

A Forecast demonstration experiment

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

Verification Domain

D-PHASE domain

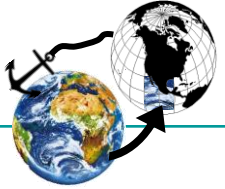


Sub-Domain

GPS network

DWD ceilometer network

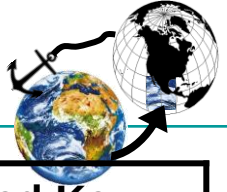
Model Selection



- All the key variables reported
- Should cover atleast **95%** of D-PHASE domain
- Data available for atleast **95%** of time

Model	Grid Spacing [km]	Forecast Range [h]	Runs /day	Nested in	Driving Global Model	Provided by
COSMO-DE	**2.8**	**21**	**8**	**COSMO-EU**	**GME (DWD)**	**DWD**
COSMO-EU	7	78	4	GME	GME (DWD)	DWD
COSMO-2	**2.2**	**24**	**6**	**COSMO-7**	**IFS (ECMWF)**	**MeteoSwiss**
COSMO-7	7	72	2	IFS	IFS (ECMWF)	MeteoSwiss
COSMO-IT	**2.8**	**30**	**1**	**COSMO-ME**	**IFS (ECMWF)**	**CNMCA**
COSMO-ME	7	72	1	IFS	IFS (ECMWF)	CNMCA
AROME	**2.5**	**30**	**1**	**ALADIN**	**ARPEGE**	**Meteo-France**
ALADIN	9.5	30	1	ARPEGE	ARPEGE	Meteo-France
MM5_15	15	72	2	MM5_60	GFS (NOAA)	FZK IMK-IFU
MM5_60	60	72	2	GFS	GFS (NOAA)	FZK IMK-IFU
QBOLAM_11	11	48	1	QBOLAM33	IFS (ECMWF)	APAT
QBOLAM_33	33	60	1	IFS	IFS (ECMWF)	APAT
COSMO-LEPS (Ensemble size 16)	**10**	**132**	**1**		**ECMWF EPS**	**ARPS Emilia-Romagna**

GOP Observational Data



Instruments	Variables	Temporal Resolution	Spatial Resolution	Derived Key Variables
GPS	Integrated Water Vapor	15 minute	63 Stations	IWV
Ceilometer	Low Cloud Base Height	10 minute	33 Stations	Binary Low cloud cover
MSG	Cloud Occurrence Probability	1 hour	5 km	Binary High cloud cover at Ceilometer stations
	Cloud Top Pressure	1 hour	5 km	
Radar and Rain Gauge **(Disaggregation)**	Precipitation data	1 hour	7 km	Domain averaged precipitation

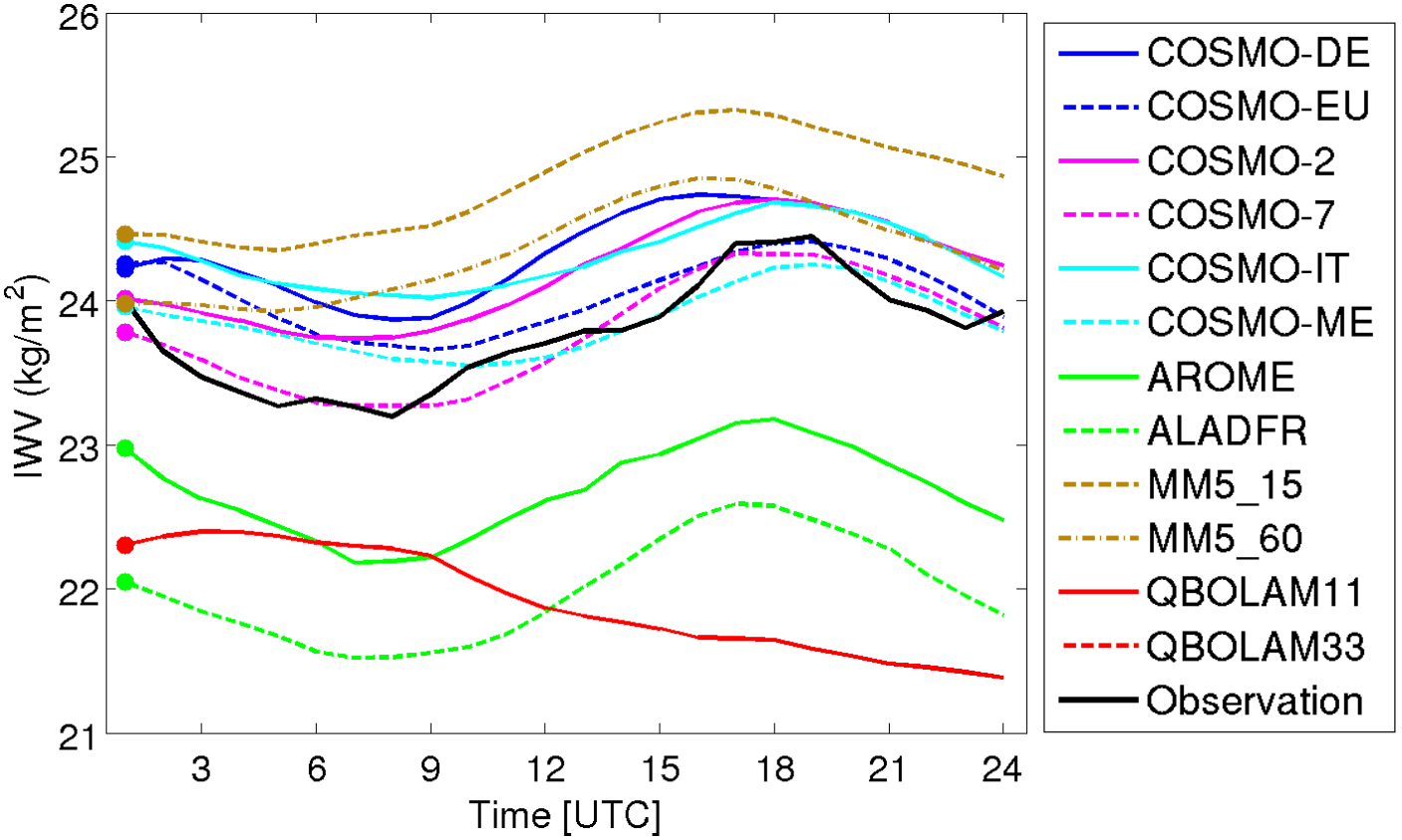
- Similar data processing for the models
- Height correction for IWV data

Diurnal Cycles

Verification performed only for Summer

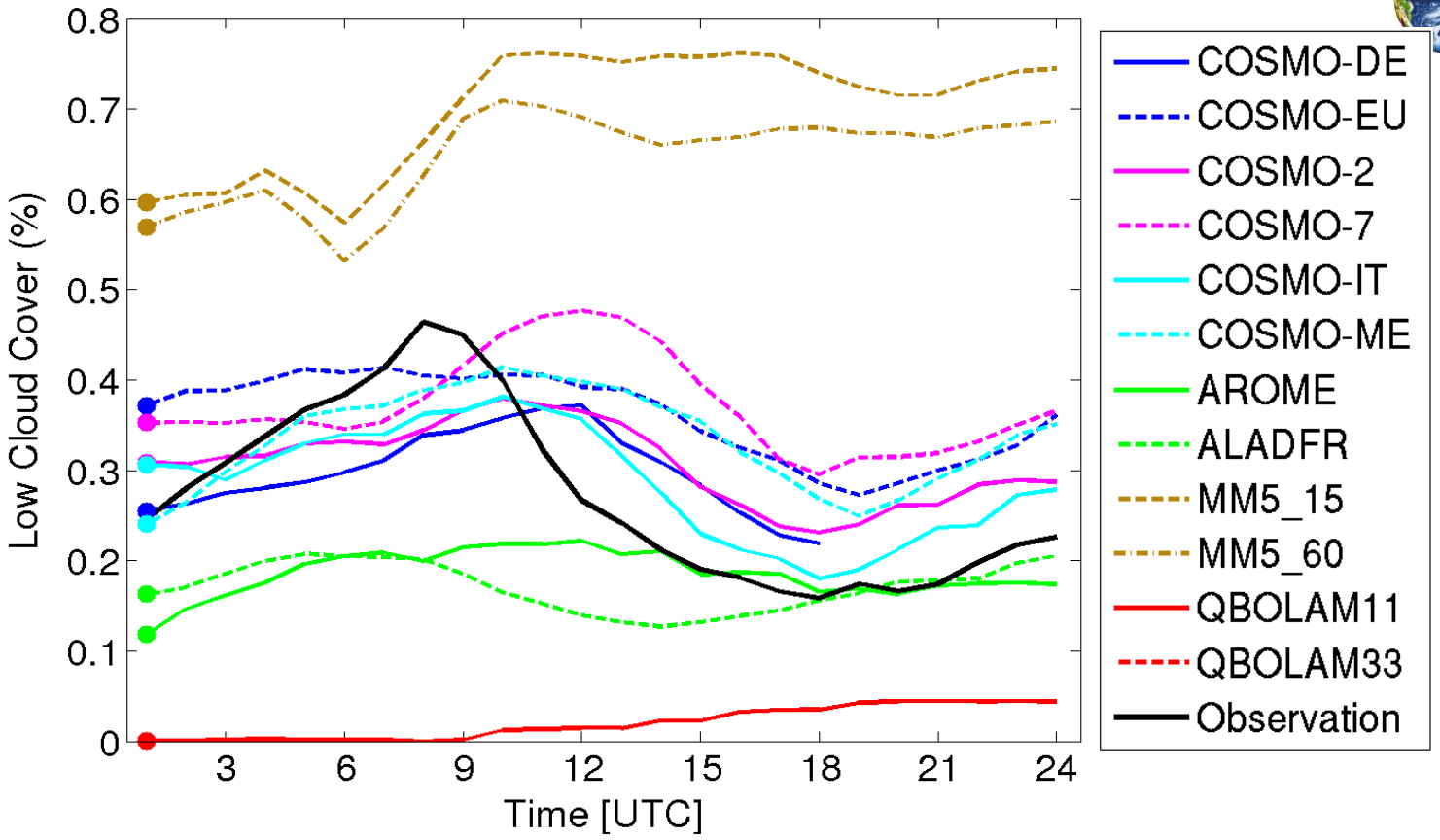
Jun – Aug 2007

Mean IWV Diurnal Cycle (00 UTC Runs)



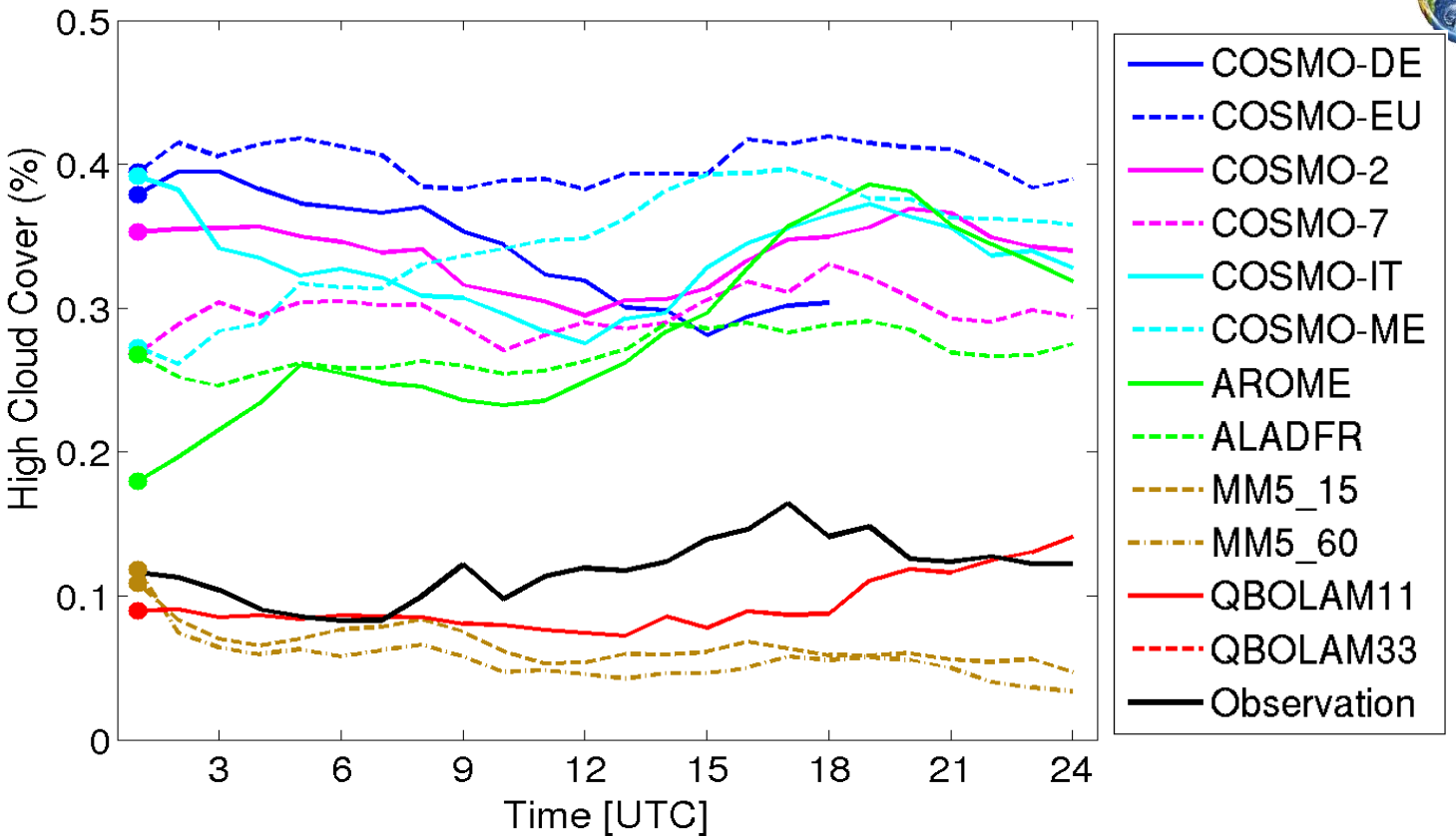
- Observed diurnal cycle well represented by most of the models
- Phase shift 0 up to - 3 hour
- Constant offset, MM5‘s are the wettest, French models are dryer, COSMO‘s seems to be in better agreement

Mean Low Cloud Cover Diurnal Cycle (00 UTC Run)



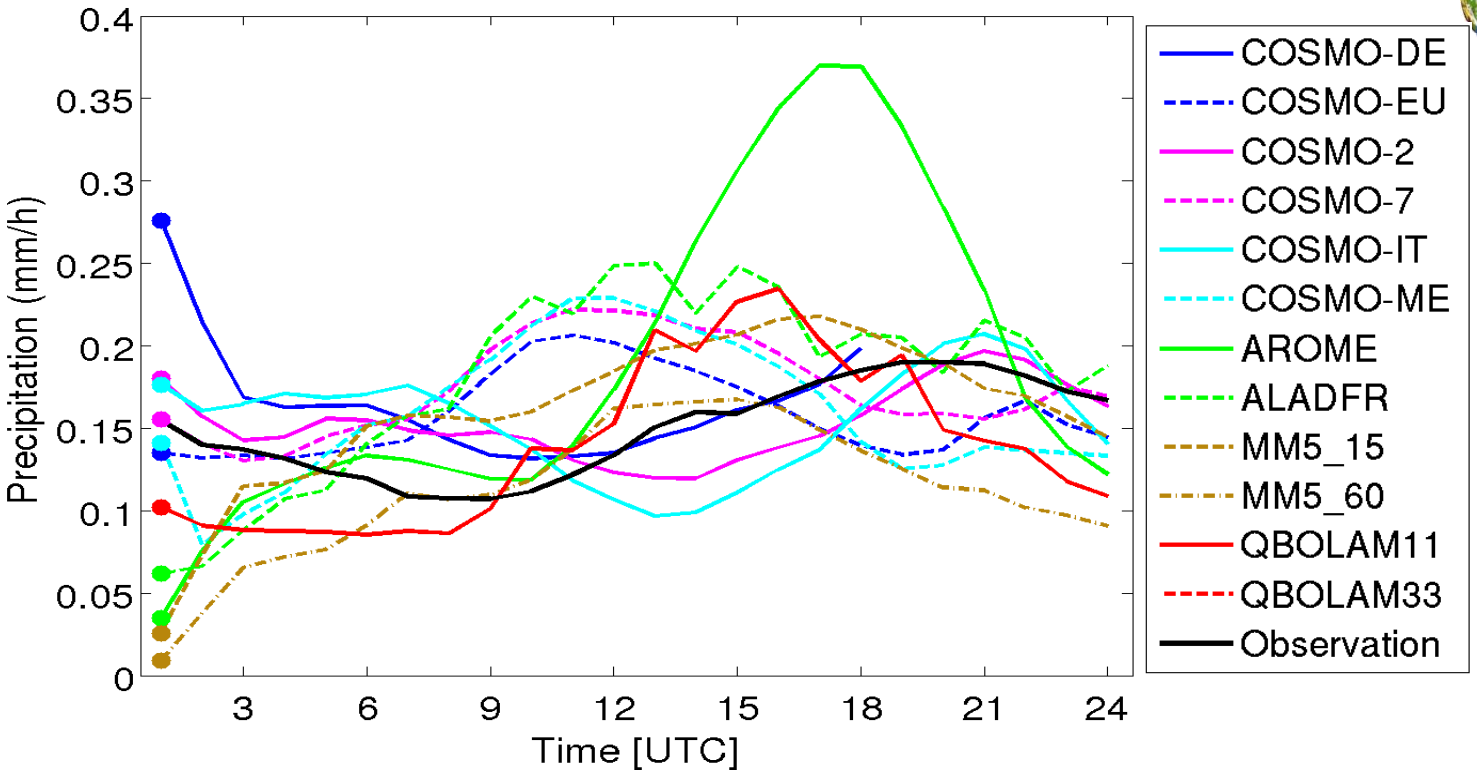
- Observed diurnal cycle well represented by most of the models
- Phase shift 2 to 4 hour
- MM5 overestimated, French and QBOLAM models underestimated and the COSMO models are in good agreement

Mean High Cloud Cover Diurnal Cycle (00 UTC Runs)



- Weak diurnal variation in both the observation and the models
- Phase shift 0 to 3 hour
- Larger offset to the observation by most of the models, while QBOLAM and MM5 are comparable to observation

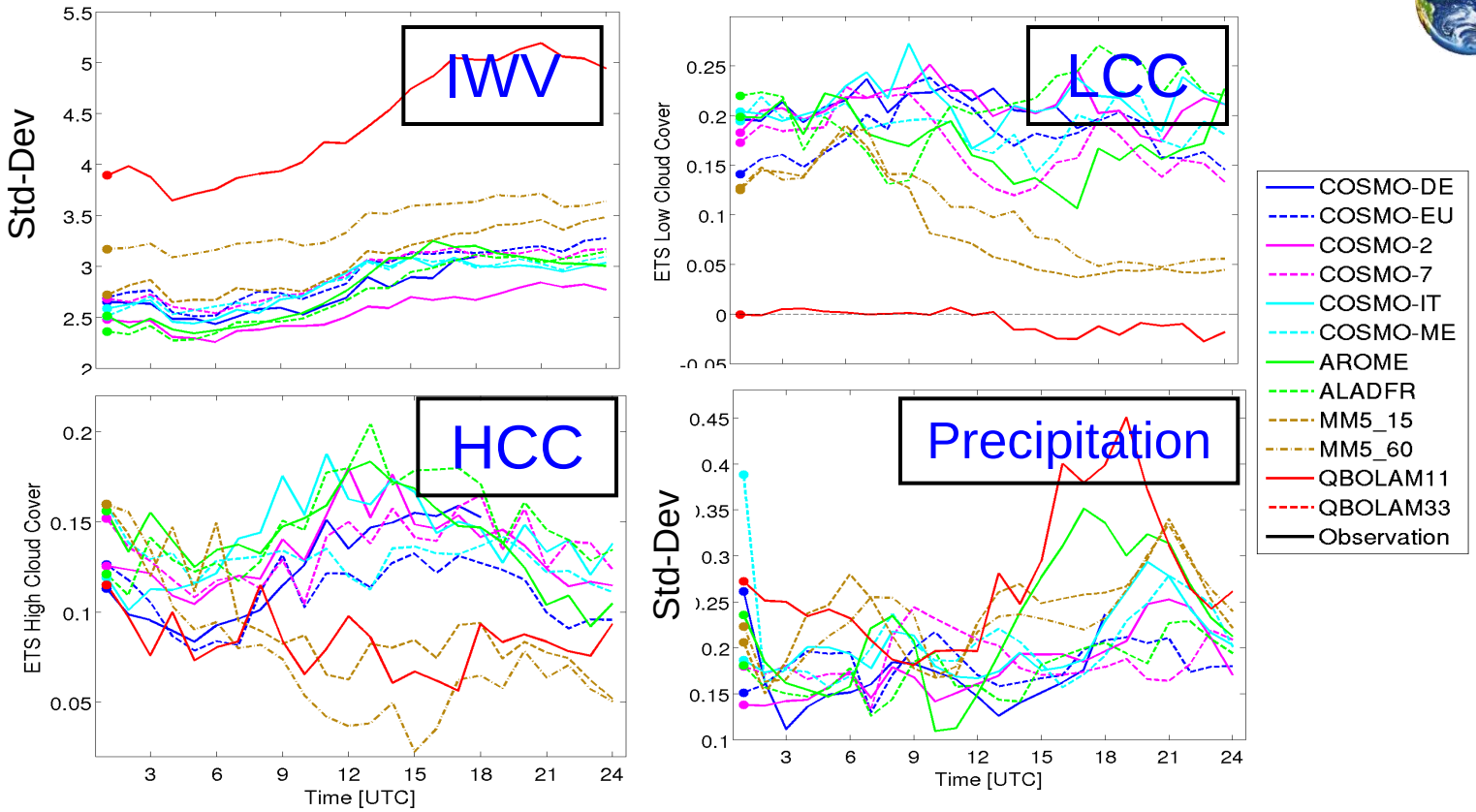
Precipitation Diurnal Cycle (00 UTC Run)



- Most of the models show the dominant spinup effect
- Precipitation is initiated earlier, in COSMO low resolution and ALADFR models, compared, to MM5 and QBOLAM models
- Phase shift: High Resolution Models 2 h, except AROME

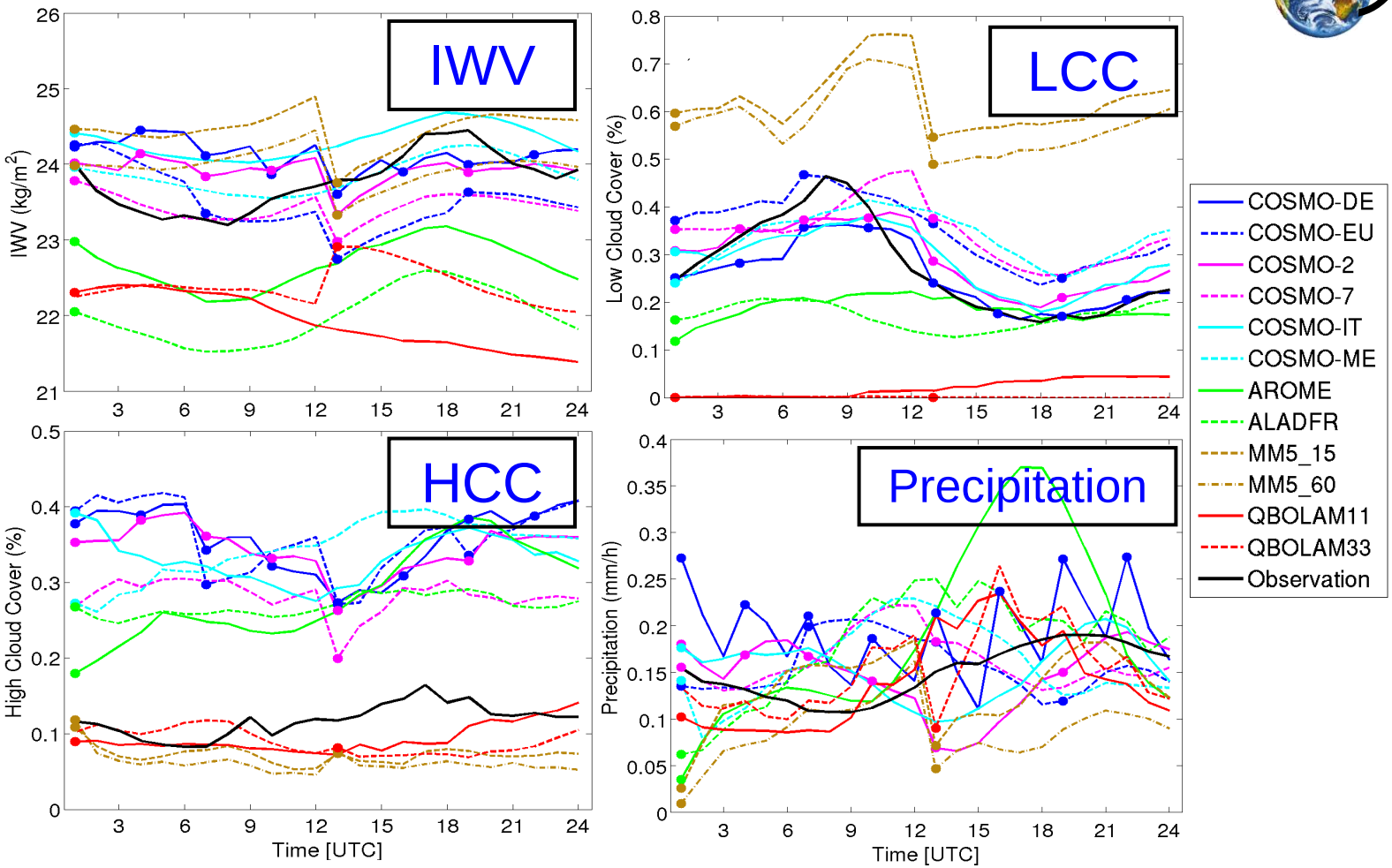
  Low Resolution Models -2 to - 8 h

Std-Dev and ETS (00 UTC Runs)



- **IWV:** Std-Dev increases with time (magnitude is twice as bias)
- **LCC:** No significant variation and very low ETS values
- **HCC:** Diurnal variation exists, but very low ETS values
- **Preci:** Std-Dev showed diurnal variation, and the values are twice larger to bias

Mean Diurnal Cycle in IWV, LCC, HCC, Preci



- Dry bias introduced due to the assimilation of day time radiosounding, is visible in all the variables, like, IWV, LCC, HCC, and Precipitation

- Are there clusters of models revealing the same kind of model errors?
- What is the most important factor, (e.g. boundary conditions, model formulation or resolution) affecting the forecast performance?

Rank Correlation

Rank Correlation (IWV, LCC, HCC):

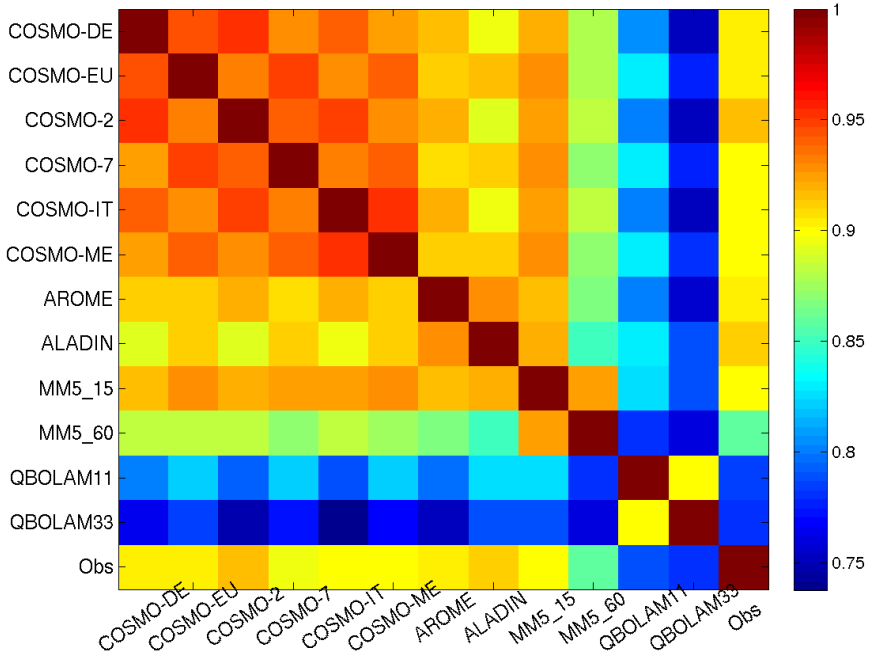
Calculated for each stations

Rank Correlation (Precipitation):

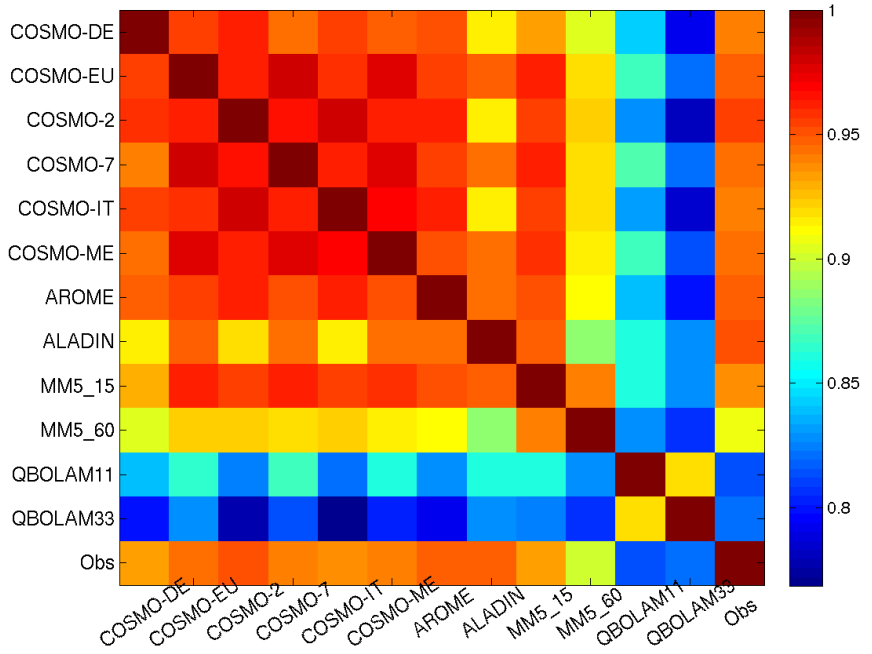
Calculated for each sub-domain

Rank Corr of Models and Obs in IWV

Hourly



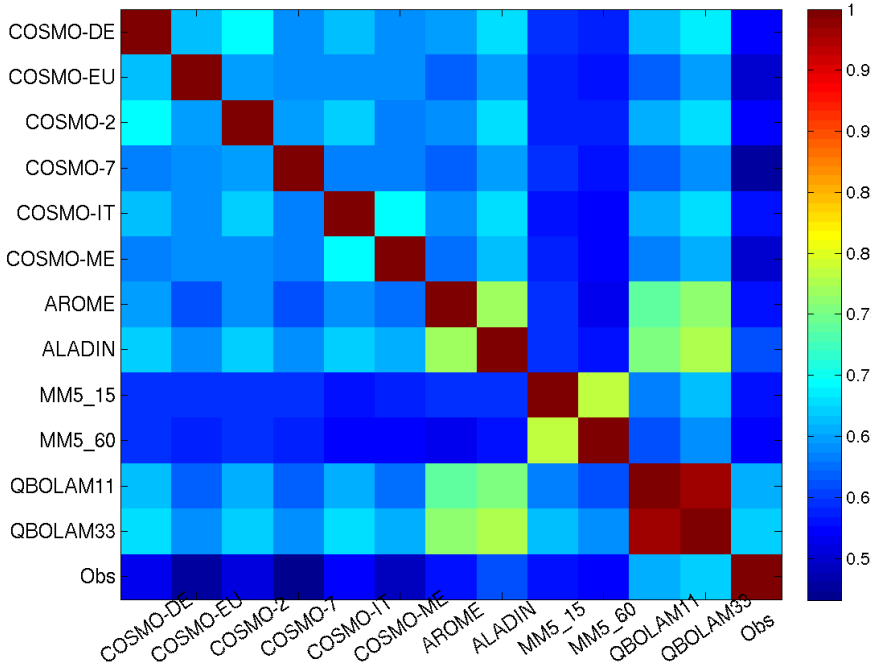
Daily



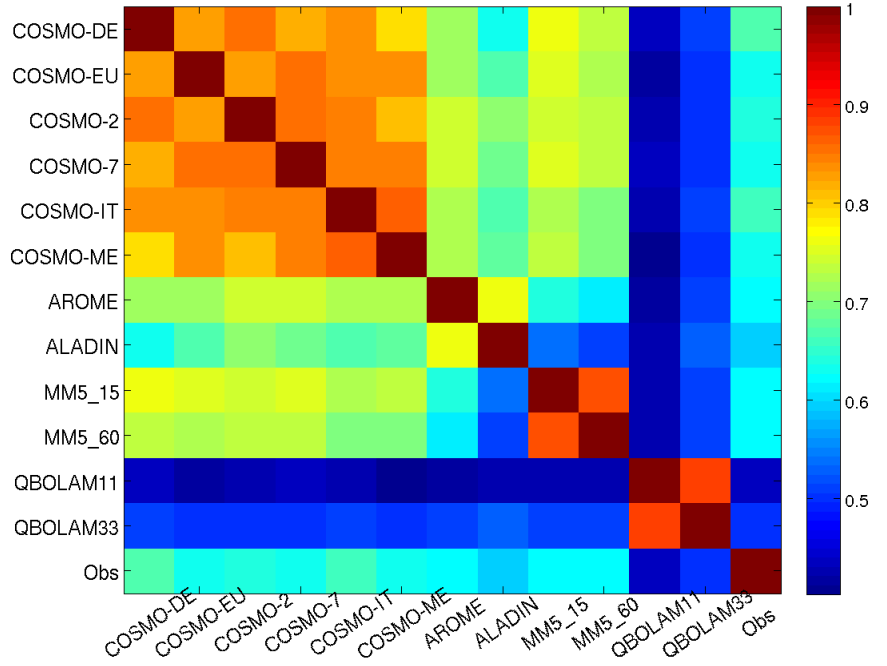
- Models with the same formulation are clustered together
- Models nested in each other are similiar
- Averaging, increases the Rank correlation

Rank Corr of Models and Obs in LCC

Hourly



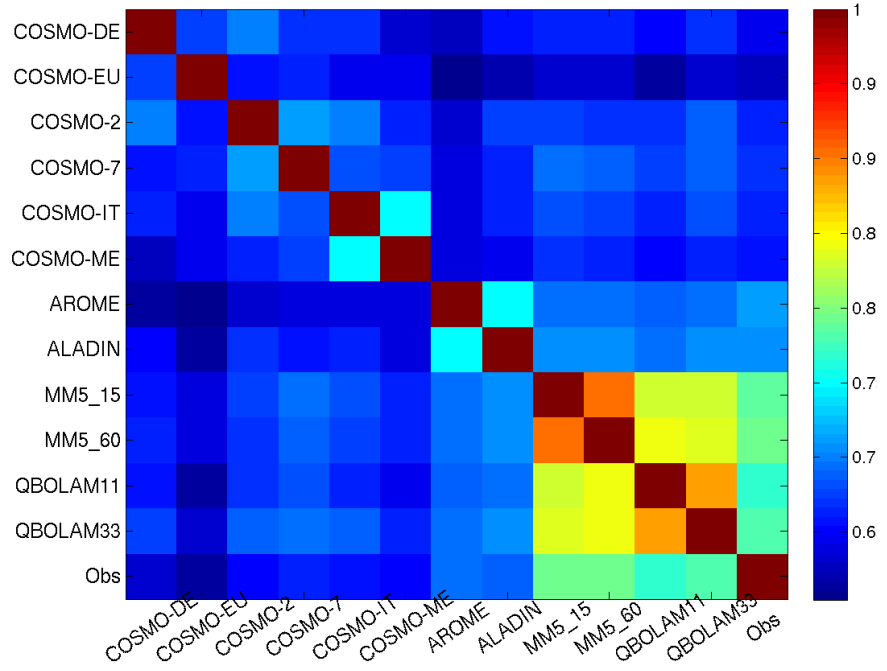
Daily



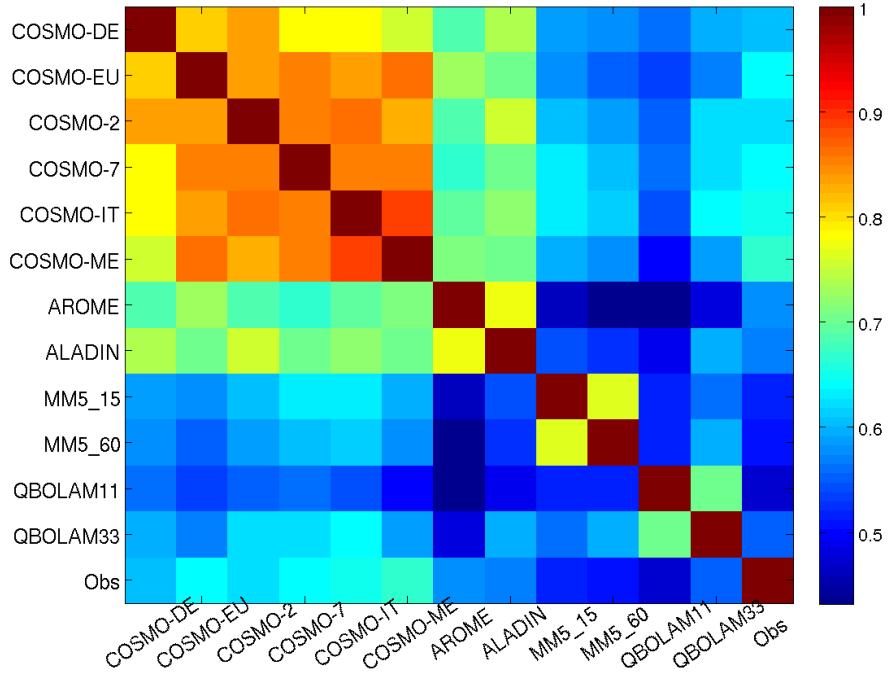
- Models with the same formulation are clustered together
- Models nested in each other are similiar
- Overall, low Rank correlation

Rank Corr of Models and Obs in HCC

Hourly



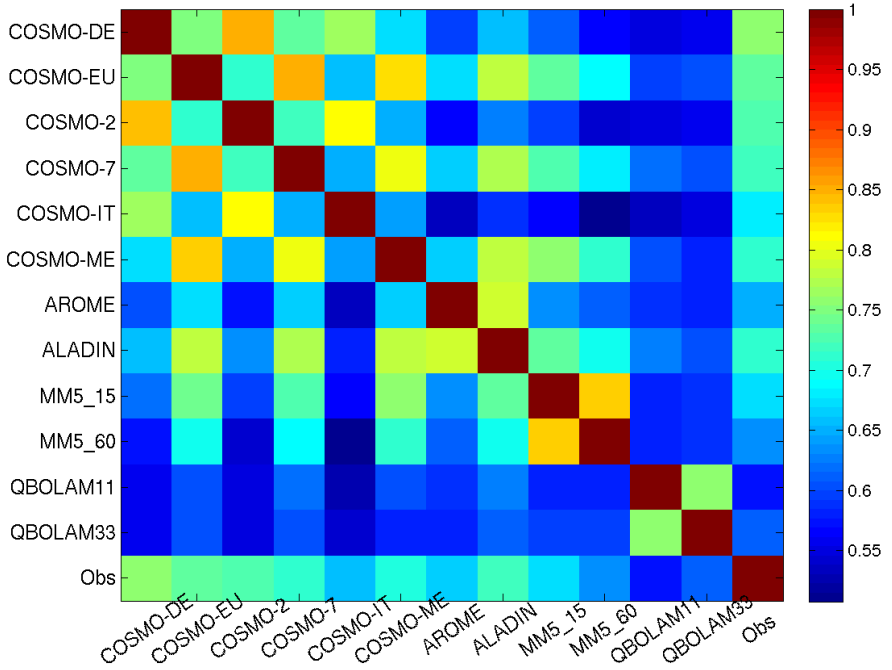
Daily



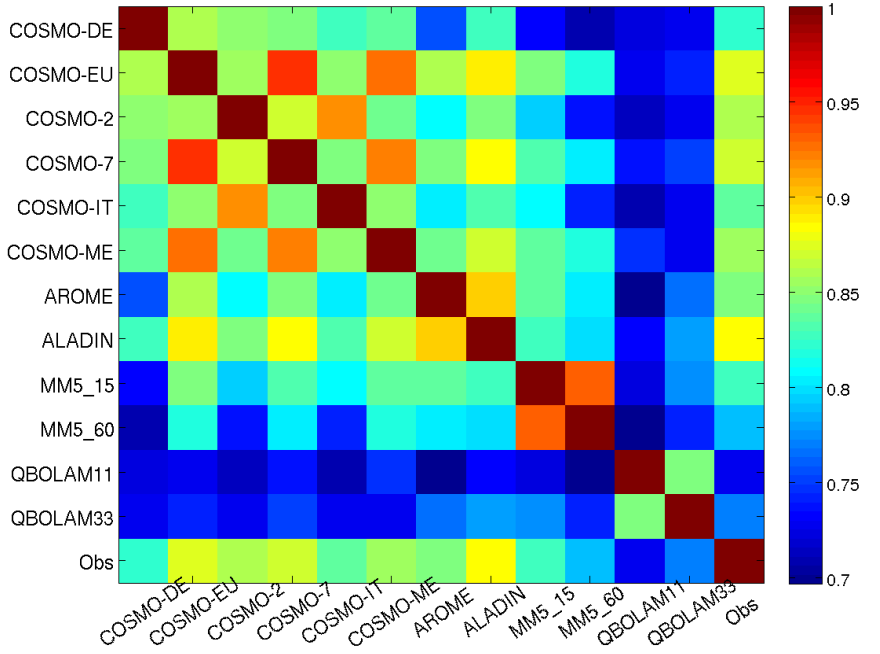
- No clear clustering with model formulation
- MM5 and QBOLAM are similar
- After averaging, the models clustered, according to their formulation

Rank Corr of Models and Obs in Preci

Hourly

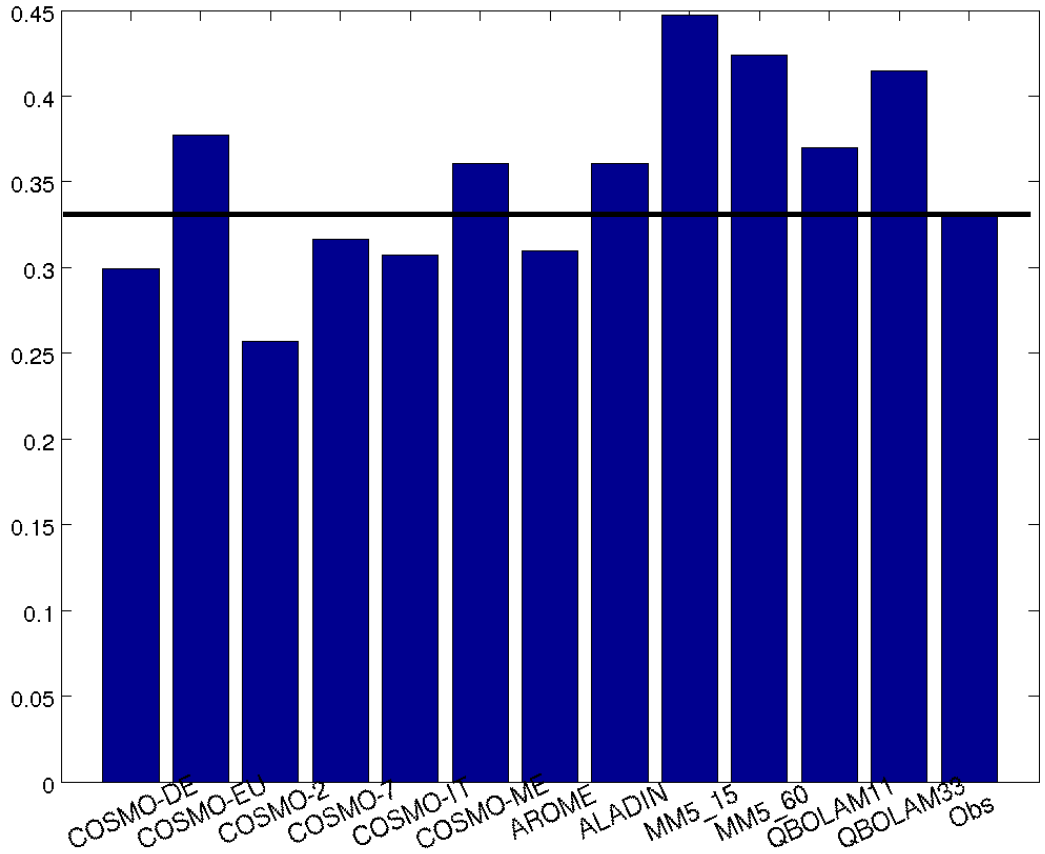


Daily



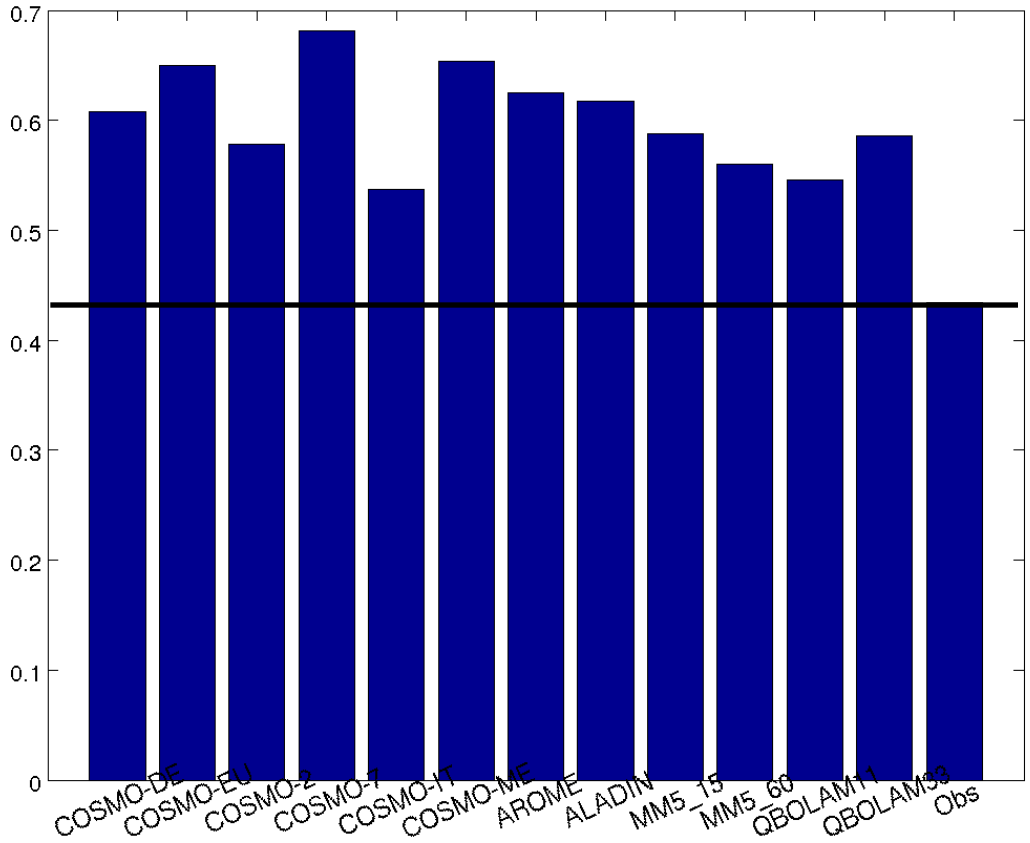
- Models clustered according to resolution

Rank Corr of IWV and Preci



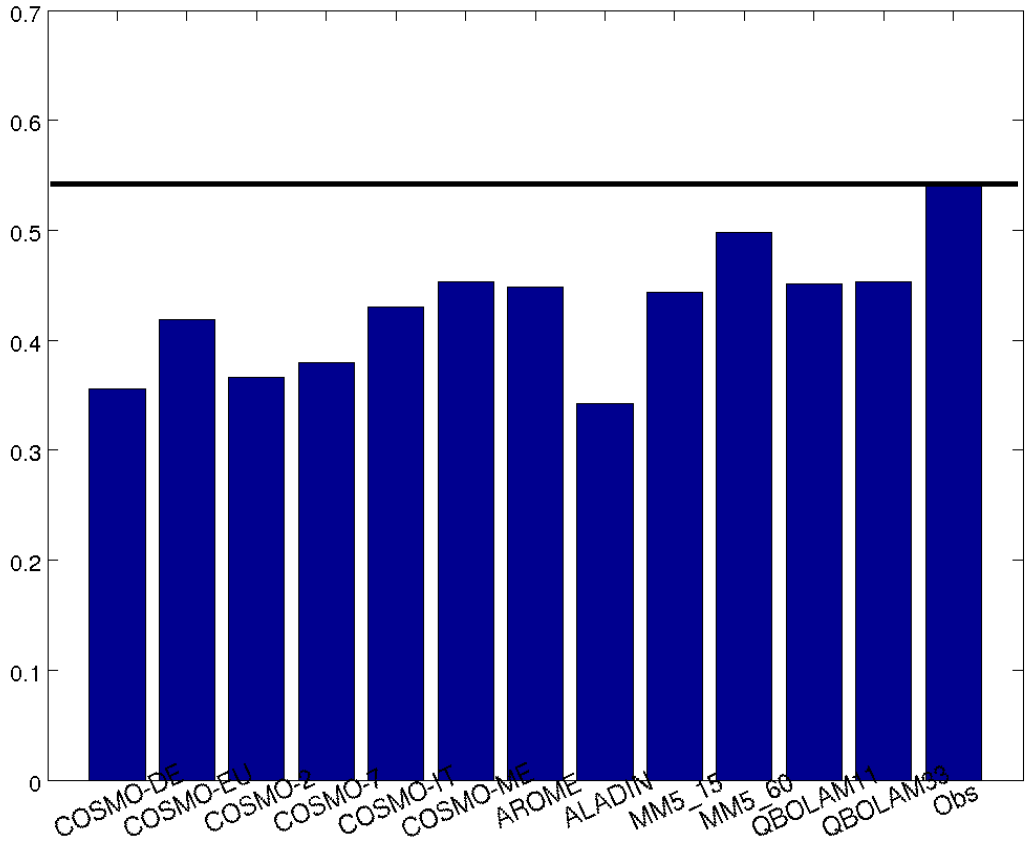
- Low rank correlation in observation
- Models shows similar strength

Rank Corr of LCC and Preci



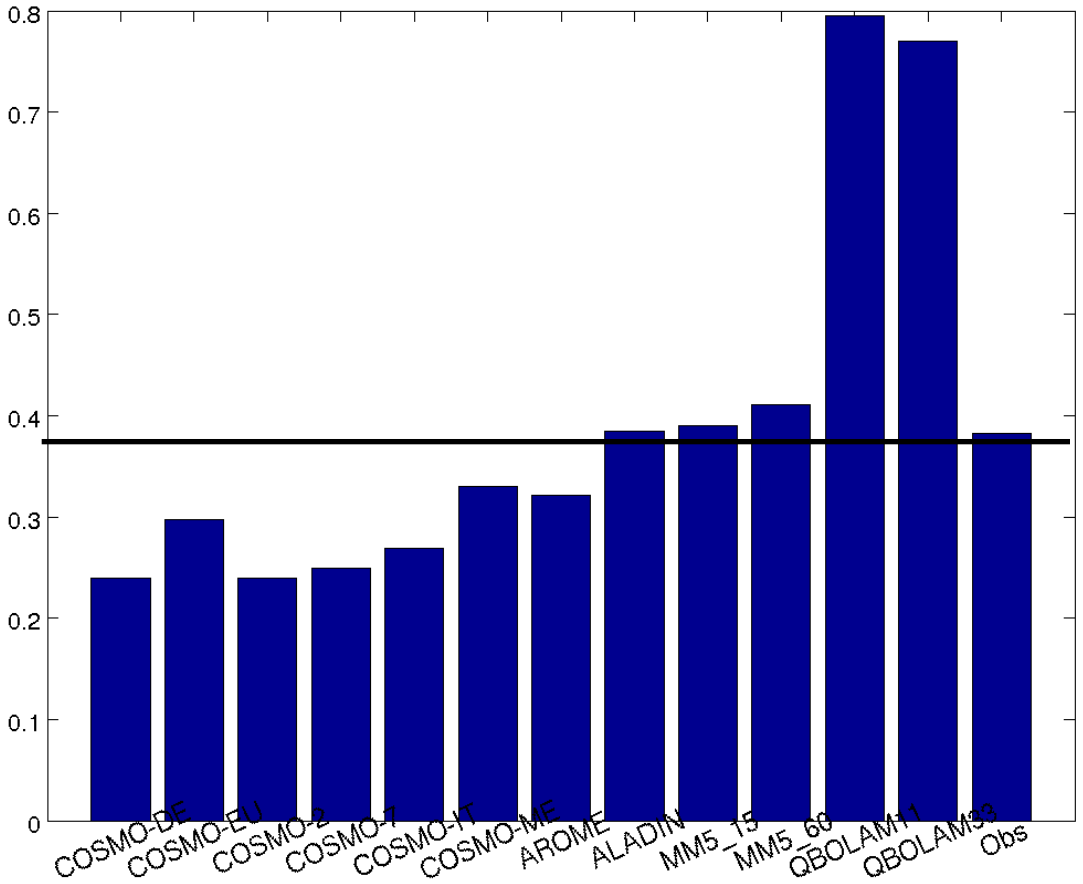
- Low rank correlation in observation
- Models shows higher strength

Rank Corr of HCC and Preci



- Good rank correlation in observation
- Models shows weaker strength

Rank Corr of LCC and HCC



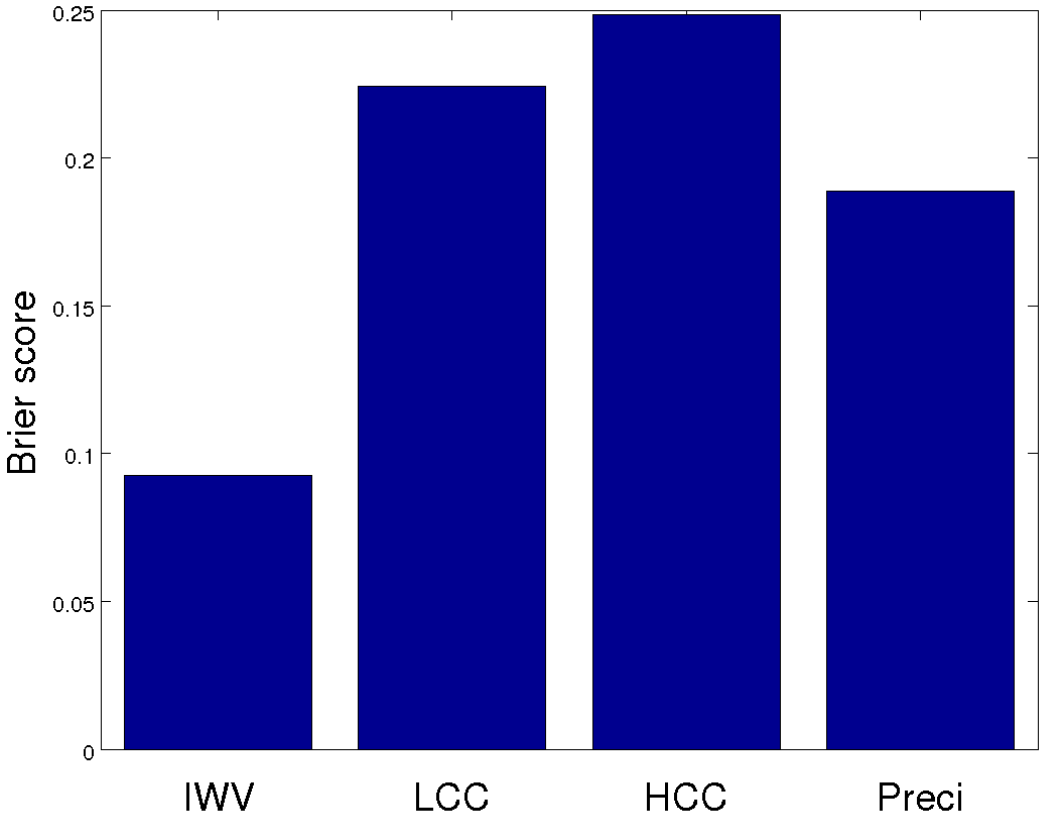
- Low rank correlation in observation
- Models shows similar strength, except QBOLAM

Verification of COSMO-LEPS Ensemble

Verification performed only for Summer

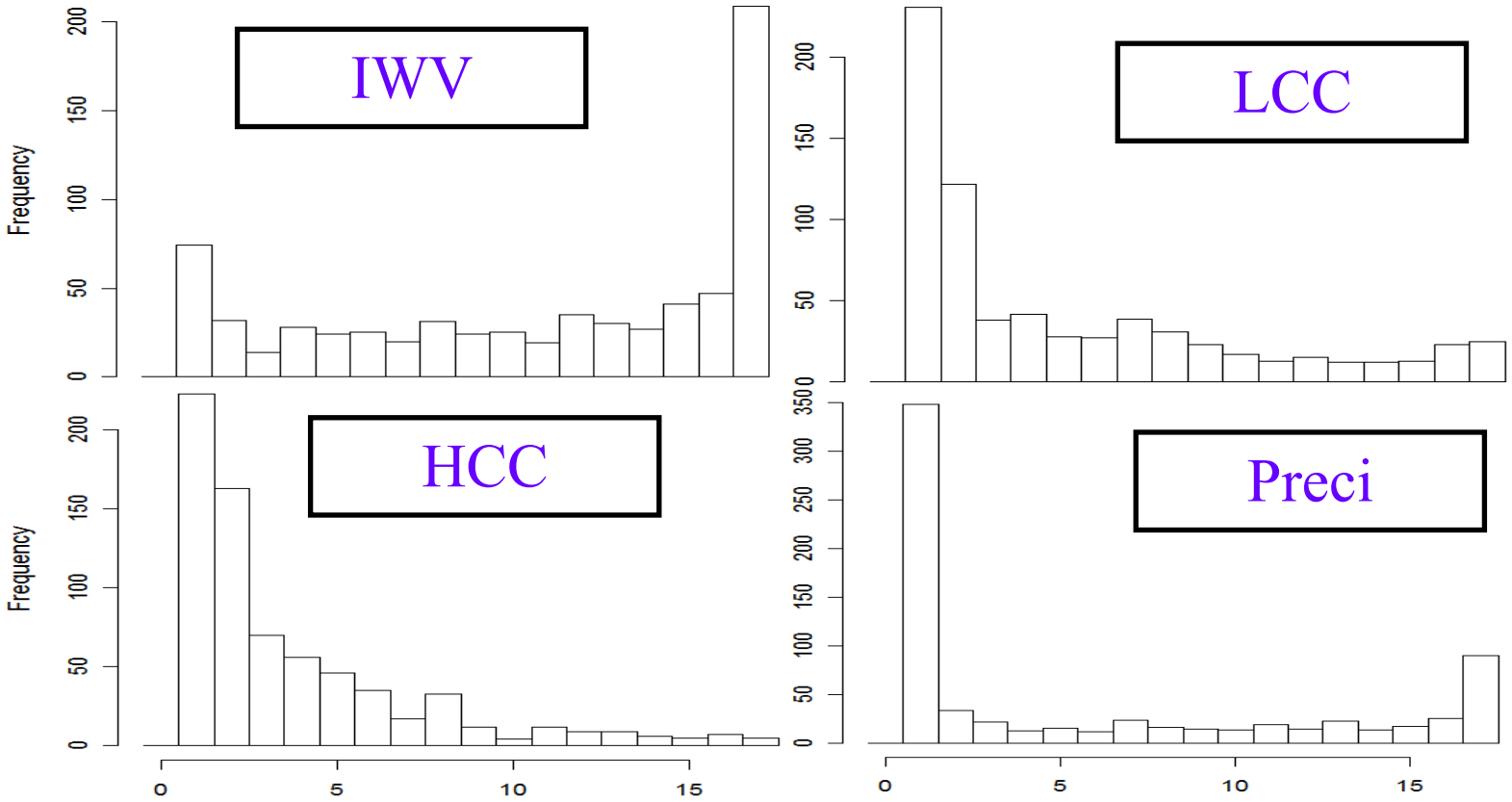
Jun – Aug 2007

Brier Score for IWV, LCC, HCC, and Preci



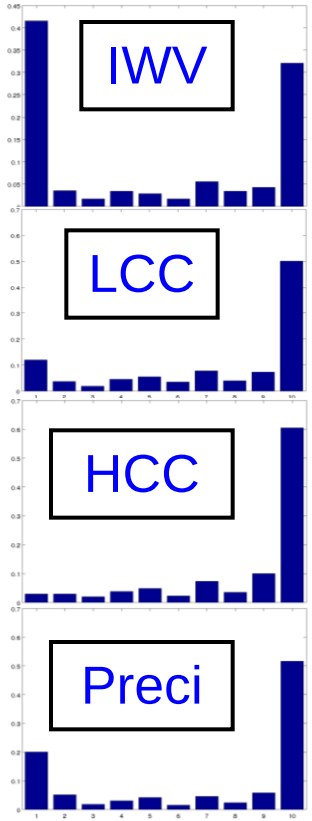
- Brier score is least for IWV, largest for the cloud cover, and intermediate for precipitation

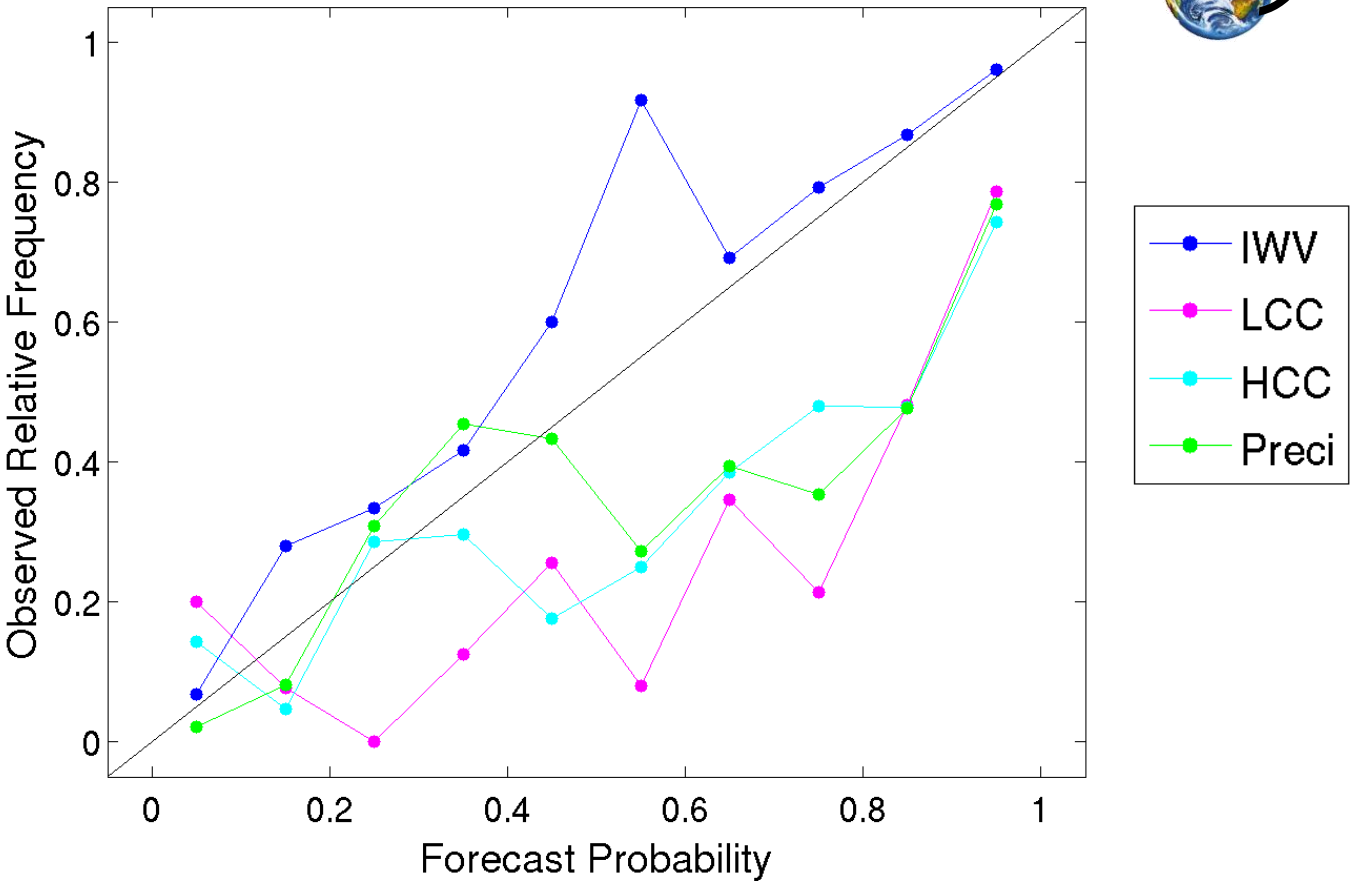
Rank Histogram



- Ensemble spread small for IWV, with dry bias
- LCC and HCC ensemble shows, the clear overforecasting, with positive bias
- For Precipitation ensemble spread is small with overforecasting

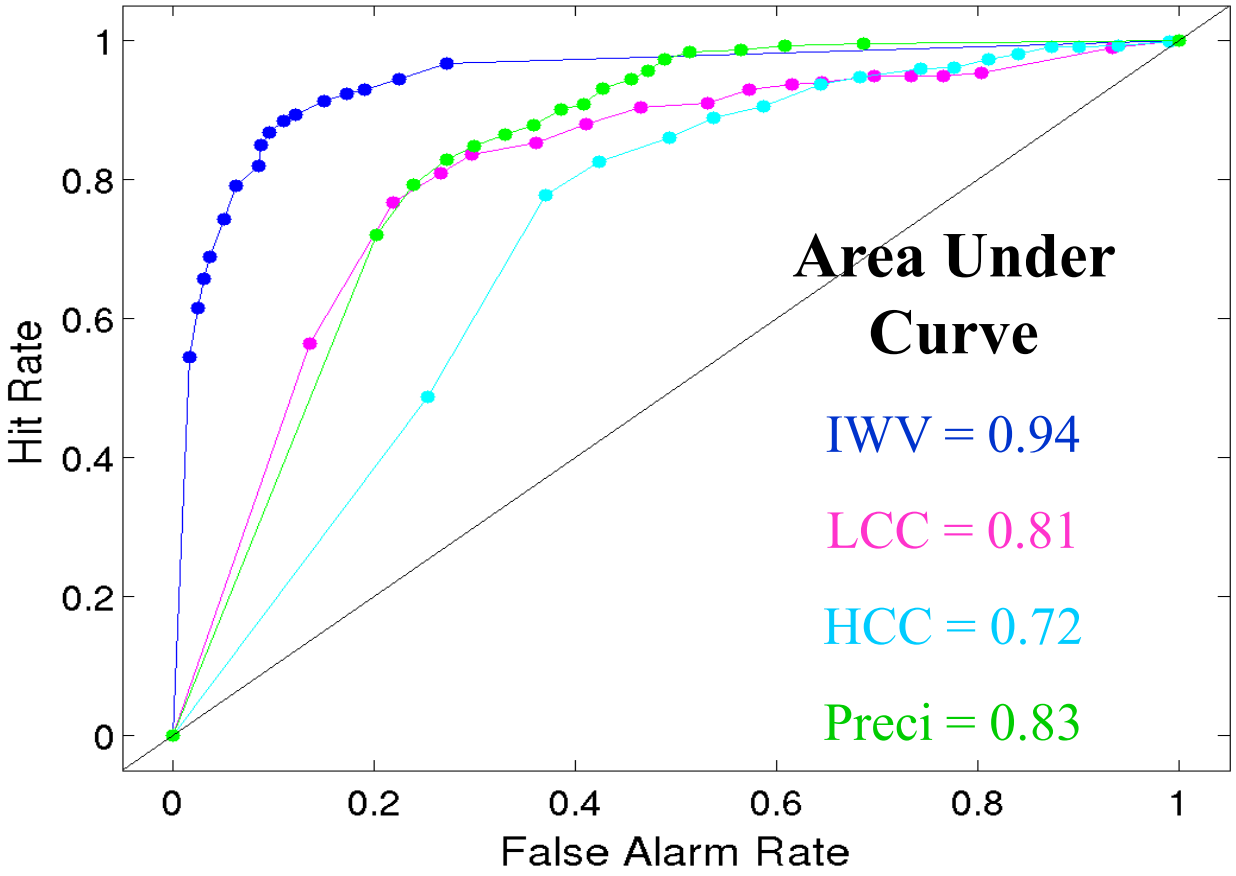
Reliability plot for IWV, LCC, HCC, and Preci





- IWV is underforecasted, probabilities are consistantly too small, mis-calibrated forecast (unconditional bias)
- For LCC, HCC, and Precipitation overforecasting with poor resolution (Conditional bias)

ROC Curve for IWV, LCC, HCC, and Preci

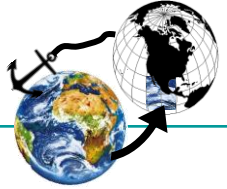


- Ensemble clearly discriminate the forecast for IWV
- Lowest resolution for the cloud cover, while precipitation have the intermediate resolution

Conclusions

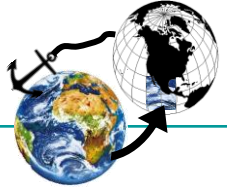
Diurnal Cycle (D-Phase Domain)

- Diurnal cycle in all variables are fairly well represented by most of the models but with the phase shift with obs.
- Diurnal cycle in precipitation shows clear dependency on the models resolution.
- The impact of data assimilation is clearly seen in all variables.
- The high resolution models does not shows any clear improvement over low resolution models.



Multivariate Relationship

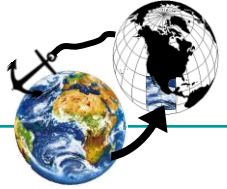
- For IWV, LCC and HCC, Models are clustered with their formulation, but, for precipitation models are clustered with their resolution
- The high resolution models didn't show any significant improvement over the low resolution models (… in all key variables)
- Models with same initial conditions didn't show any similarity, however model nested in each other show similar behavior.
- No clear association between IWV and precipitation is observed, in both observation and models
- Modeled Precipitation is over-associated with modeled LCC, but under-associated with modeled HCC, compared to observation



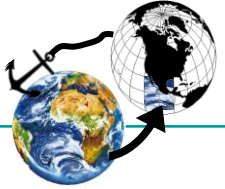
Ensemble Verification

- Ensemble show dry bias for IWV, and, wet bias for cloud cover and Precipitation.
- Small ensemble spread for IWV and Precipitation.
- Clear over-forecasting of cloud cover.
- Ensemble clearly discriminated event for IWV, while poorly discriminated for cloud cover.

What's Next



- Explore in details D-PHASE Ensemble systems



Thank You