

Evaluation of the tropical water vapor of CMIP6 GCMs with ESA CCI+ “Water Vapor” climate data records: Insights from large-scale atmospheric circulation

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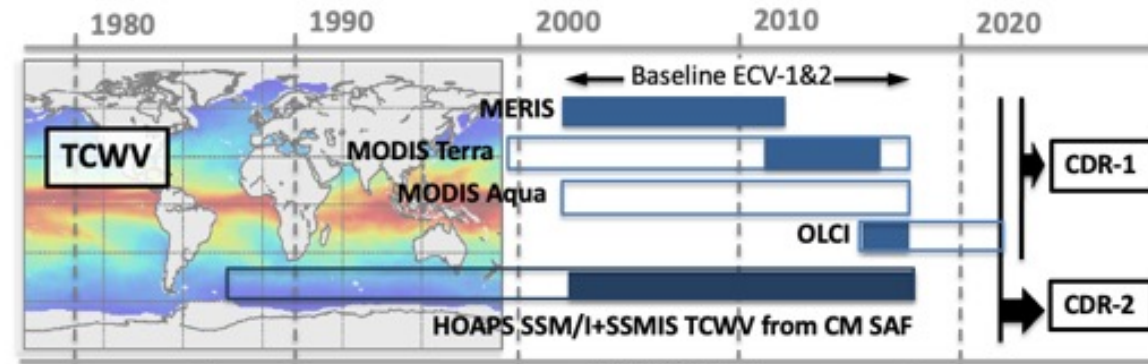
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1. Data Description

CCI CDR_2:

- NIR observations over land (MERIS, MODIS/Terra, OLCI), daytime only
- Microwave over ocean (SSM/I and SSMIS)
- 0.5 degree spatial resolution
- 2003-07 ~ 2017-12
- **Daily mean (daytime only), clear over land**
- **Daily mean, not heavily precipitable over ocean**



<https://climate.esa.int/en/projects/water-vapour/about/>

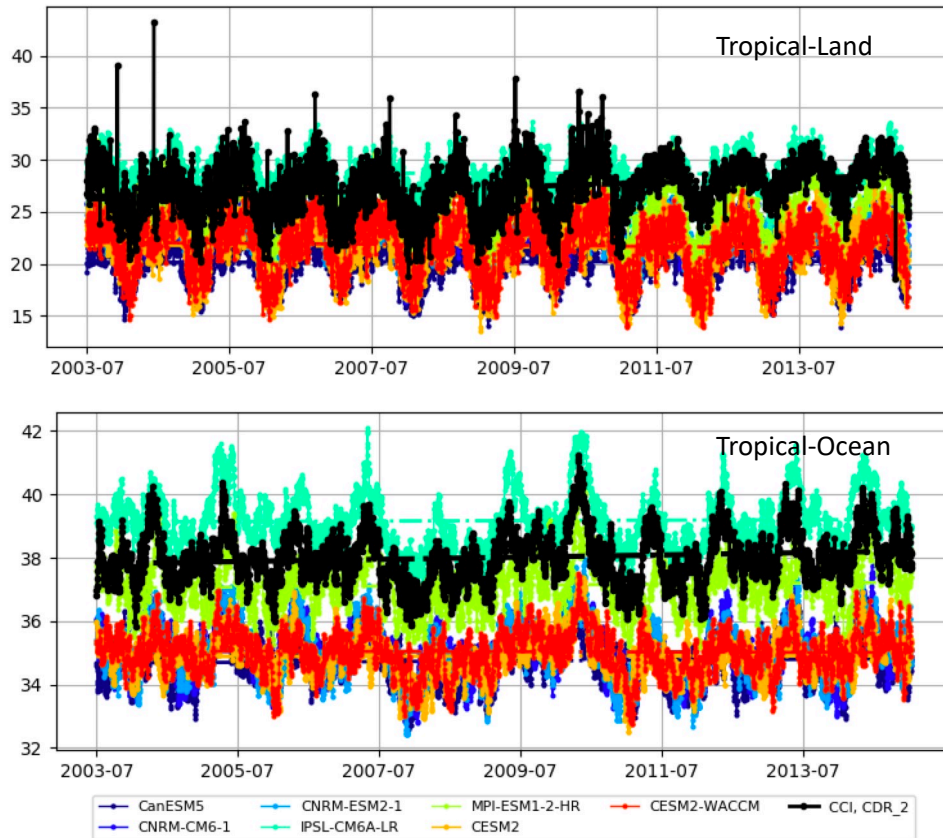
CMIP6 Models:

- 7 models from 5 Institution via the ESFG node of IPSL;
- Amip simulations
- Daily data
- Mostly from 1979-01 ~ 2014-12
- **Daily mean, cl<50% over land**
- **Daily mean, pr<0.001mm over ocean**

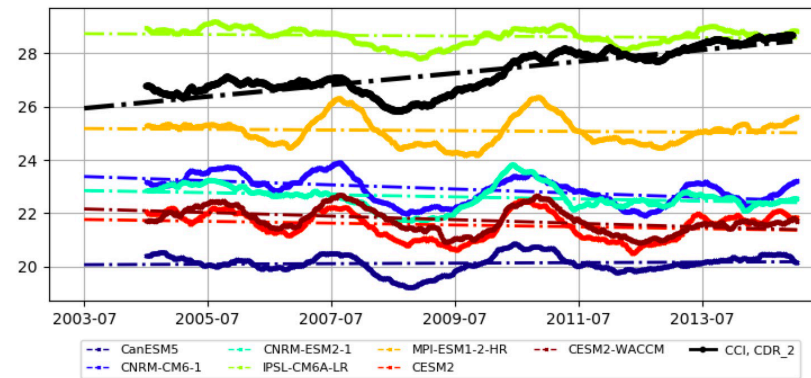
Institution	Model ID	Variable	Grid Resolution	Start-time	End-time
CCCma	CanESM5	hus,cl,pr,wap	64*128	1950-01	2014-12
CNRM-CERFACS	CNRM-CM6-1	hus,cl,pr,wap	128*256	1979-01	2014-12
	CNRM-ESM2-1	hus,cl,pr,wap	128*256	1979-01	2014-12
IPSL	IPSL-CM6A-LR	hus,cl,pr,wap	143*144	1979-01	2014-12
MPI-M	MPI-ESM1-2-HR	hus,cl,pr,wap	192*384	1979-01	2014-12
NCAR	CESM2	hus,cl,pr,wap	192*288	1979-01	2014-12
	CESM2-WACCM	hus,cl,pr,wap	192*288	1979-01	2014-12

2. Data Analysis

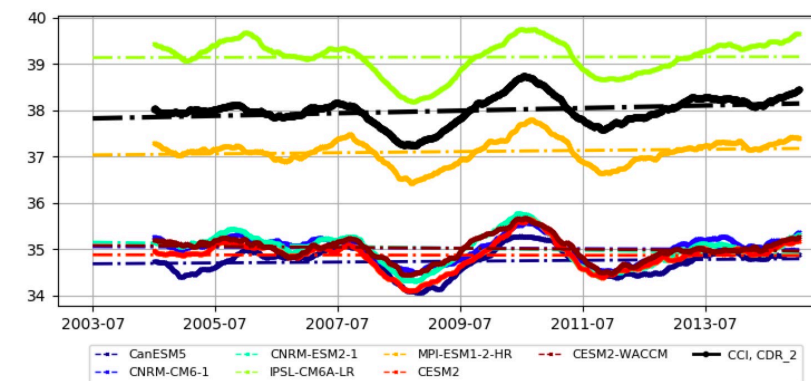
2.1 Time series of the TCWV in the Tropical Area (30S ~ 30N)



Tropical-Land



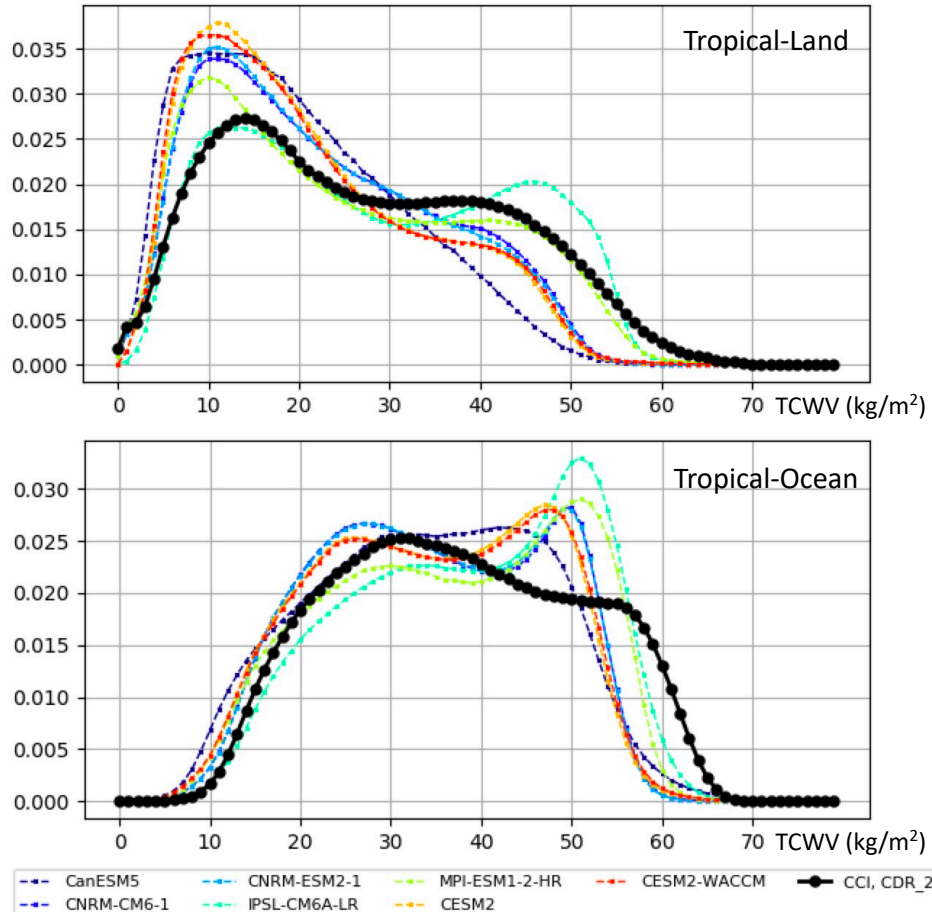
Tropical-Ocean



- Strong inter-annual variation cycle was observed over land;
- Increasing trend observed for the CCI data over land;
- Overall, the CCI_CDR2 data varies within the ensemble spread of CMIP6 Models;

2. Data Analysis

2.2 PDFs of the TCWV in the Tropical Area (30S ~ 30N)



Inter-annual variation of the mean value of the 10 percentile dry/wet end of the PDFs (the number in the parentheses demote the relative percentage of the trend))

Model	Dry-Land (kg/m ² /year)	Dry-Ocean (kg/m ² /year)	Wet-Land (kg/m ² /year)	Wet-Ocean (kg/m ² /year)
CanESM5	-0.012 (-0.25%)	-0.002 (-0.01%)	0.015 (0.04%)	0.019 (0.03%)
CNRM-CM6-1	-0.042 (-0.38%)	-0.042 (-0.38%)	0.058 (0.11%)	0.058 (0.11%)
CNRM-ESM2-1	-0.022 (-0.20%)	-0.022 (-0.20%)	0.025 (0.05%)	0.025 (0.05%)
IPSL-CM6A-LR	-0.038 (-0.29%)	-0.038 (-0.30%)	0.034 (0.06%)	0.034 (0.06%)
MPI-ESM1-2-HR	-0.035 (-0.33%)	-0.035 (-0.33%)	0.090 (0.16%)	0.090 (0.16%)
CESM2	-0.009 (-0.16%)	0.002 (0.01%)	0.028 (0.06%)	0.052 (0.10%)
CESM2-WACCM	-0.026 (-0.46%)	-0.016 (-0.11%)	0.038 (0.08%)	0.059 (0.11%)
CCI, CDR_2	-0.211 (-1.63%)	-0.211 (-1.63%)	0.026 (0.04%)	0.026 (0.04%)

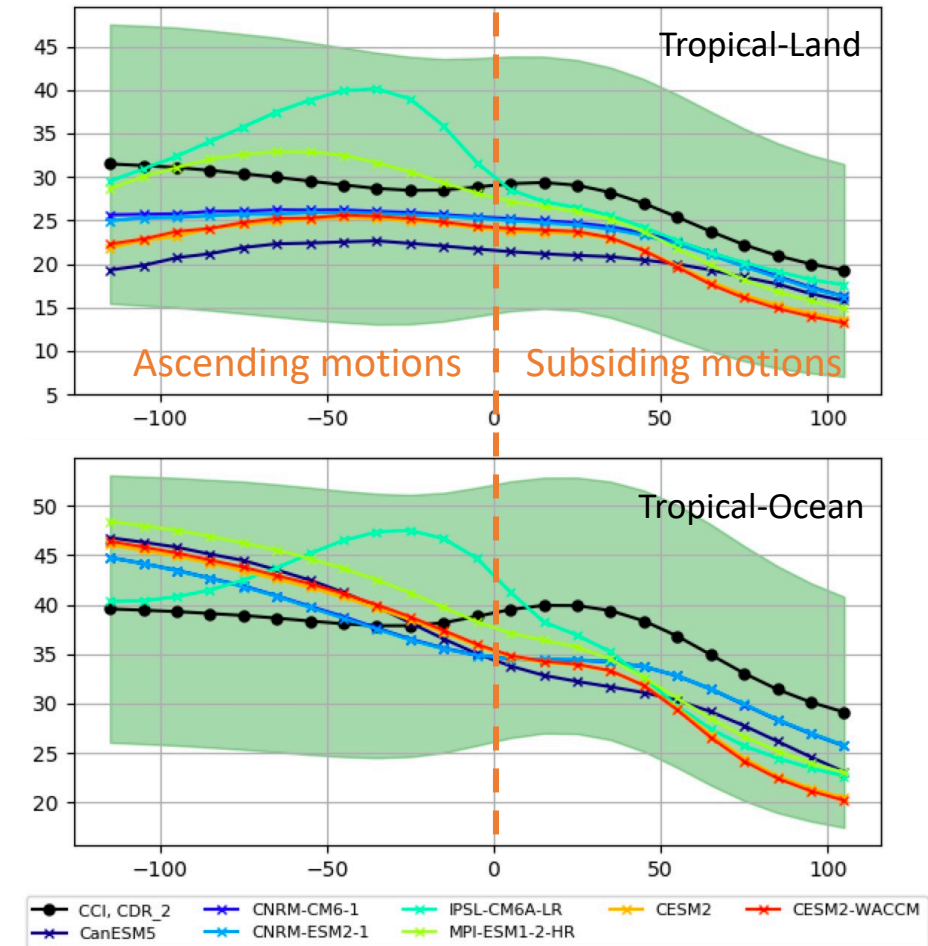
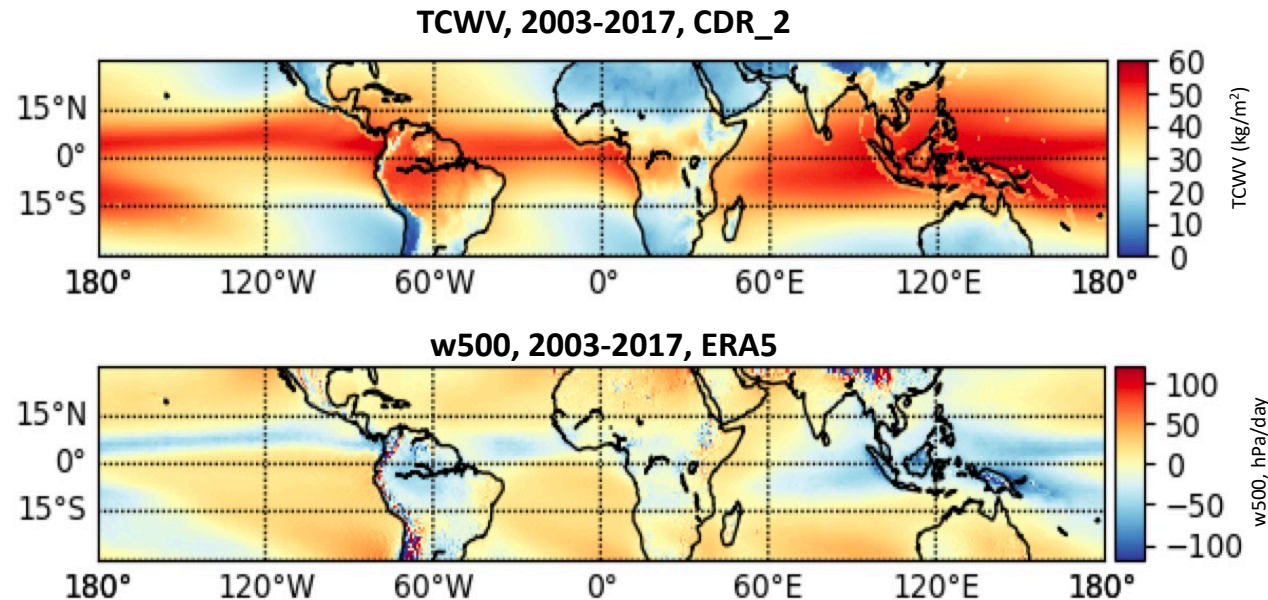
- Different PDF patterns for land and ocean;
- Dry/wet end of the PDFs of TCWV indicate ‘dry get dryer’;

2. Data Analysis

2.3 Comparison from Large-scale Circulation Aspect

Link between total column water vapor and the large-scale atmospheric circulation:

- ω_{500} to represent large-scale circulation;
- Convective motion to moist troposphere;
- Subsiding motion to dry troposphere;



ω_{500} from ERA5 is employed as reference for the CCI data.

3. Conclusions

Time series:

- Strong inter-annual variation cycle over land;
- Increasing trend observed over both land and ocean;
- Overall, the CCI_CDR2 data varies within the ensemble spread of CMIP6 Models;

PDFs of the TCWV in the Tropical Area:

- Different PDF patterns for land and ocean;
- Dry/wet end of the PDFs of TCWV indicate ‘dry get dryer’;

Large-scale circulation and TCWV:

- Convective motion related to moist troposphere and subsiding motion to dry troposphere;
- All CMIP6 models varies within the standard deviation of each circulation bins of ω 500 CCI_CDR2 data;