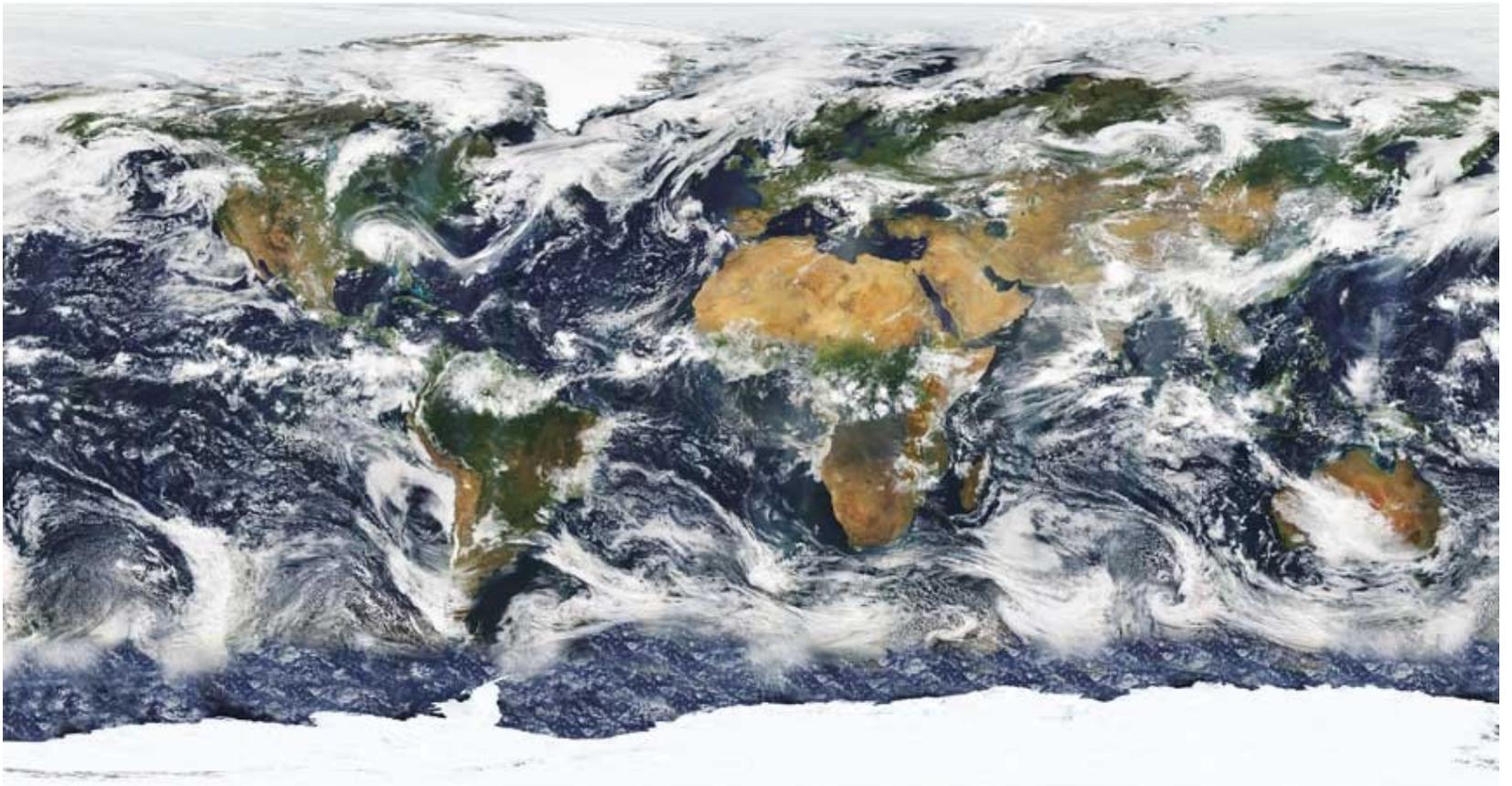


# Cloud regimes and relation to precipitation globally and over the Mediterranean region

Dimitra Konsta, George Tselioudis, Vasso Kotroni, Kostas Lagouvardos



## Precipitation trends over the Mediterranean region

→ Several observational studies have shown **negative precipitation trends over the Mediterranean** region during the last few decades (Mariotti et al. 2015, Shohami et al. 2011, Philandras et al. 2011, Xoplaki et al. 2004, Quereda Sala et al. 2000, Schonwiese and Rapp 1997)

→ Models projections agree on a robust picture of future climate change over the Mediterranean, consisting of **a pronounced decrease in precipitation** (Polade et al. 2017, Giorgi and Bi 2005) or RCMs (Somot et al. 2008, Gao et al. 2006, Ulbrich et al. 2006)

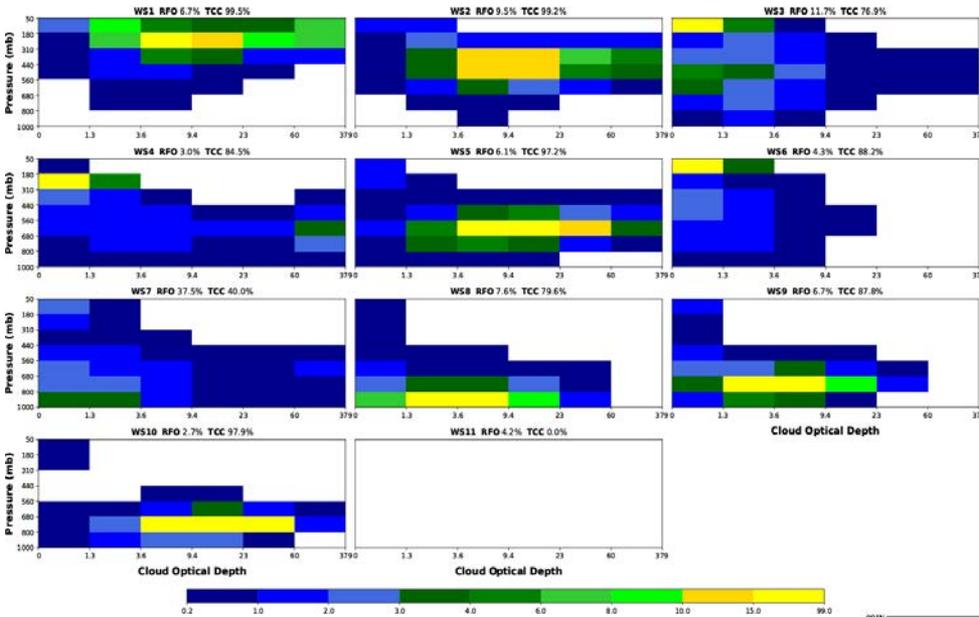
+ economic and social vulnerability of densely populated region and growing urban water demands → precipitation is a key variable in the Mediterranean region

→ Which are the mechanisms responsible for the precipitation decrease?

Need of studying precipitation in the context of specific atmospheric weather regimes.

# ISCCP-H Global Weather States

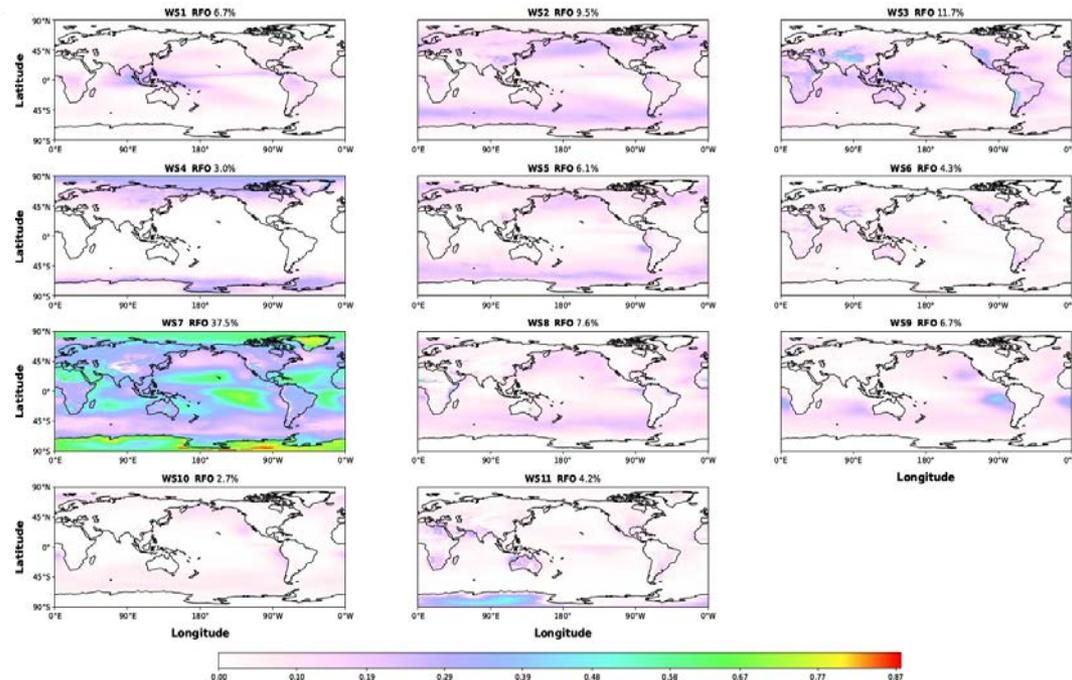
Mean PC-r Plots for HGG Global Domain (Weather States)



## Release of New ISCCP HGG Cloud Dataset

- Higher Resolution Sampled Satellite Retrievals (from 30 to **10 km**)
- Higher Resolution Gridded Products (from 2.5°x2.5° to **1°x1°**)
- Expanded Period of Record (from 1983 – 2009 to 1983 – **2015**.....)

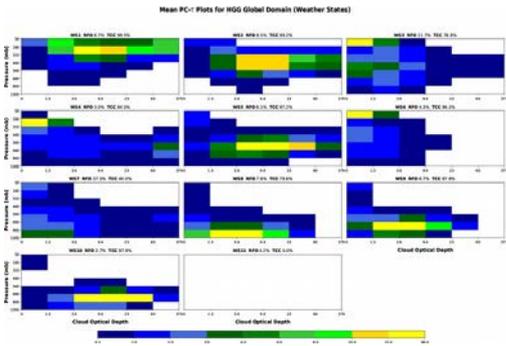
Geographic Distribution of Weather States for HGG Global Domain



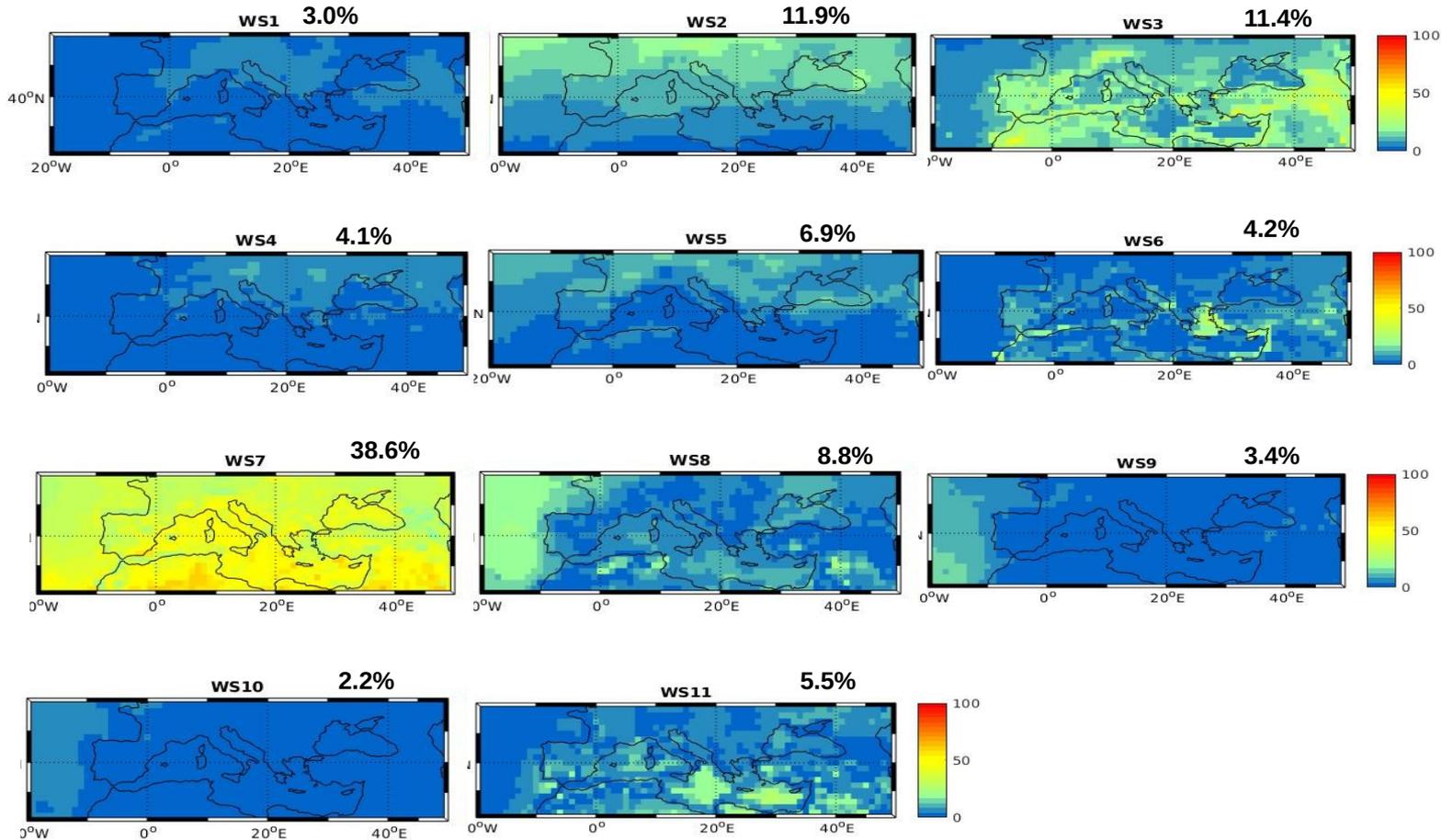
Global Weather States (WS) derived through cluster analysis of ISCCP-H TAU-PC histograms:

- 10 WS going from deep convective to stratocumulus clouds
- Overall, new WS very similar to ISCCP-D ones
- Merging of shallow cumulus and thin stratocumulus D-WS
- Very different polar WS better confined in polar regions

# Geographic Distribution of Weather States for the Mediterranean region

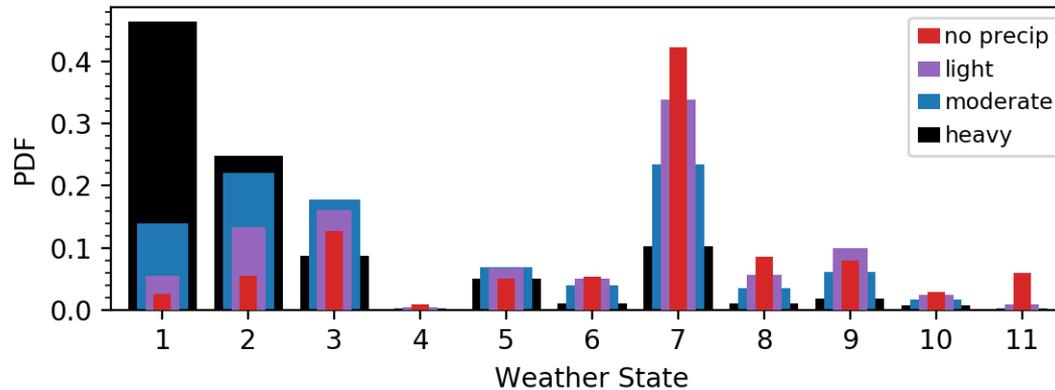


- Fair weather WS7 the most frequent, as in the global domain
- Storm cloud WS2 second most frequent, occurring more in the northern half of the region, followed by the thicker cirrus WS3
- Deep convective WS1 less frequent than in the global domain, occurring in northern continental regions

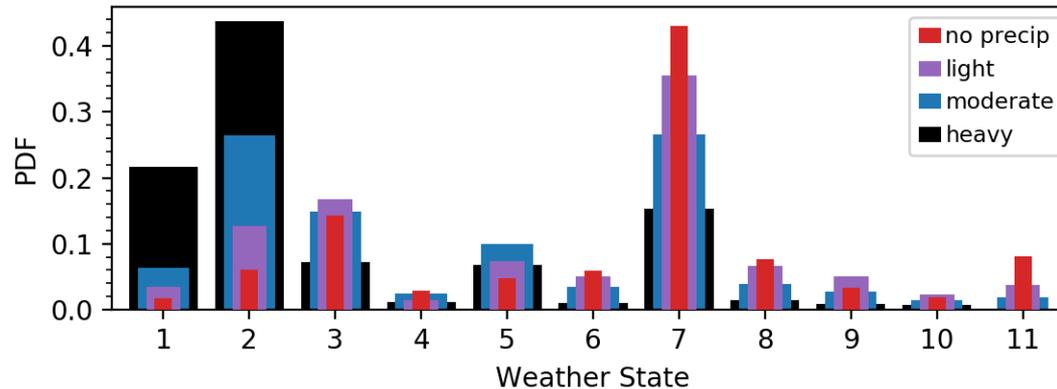


# Precipitation distribution in cloud-defined Weather States

Global



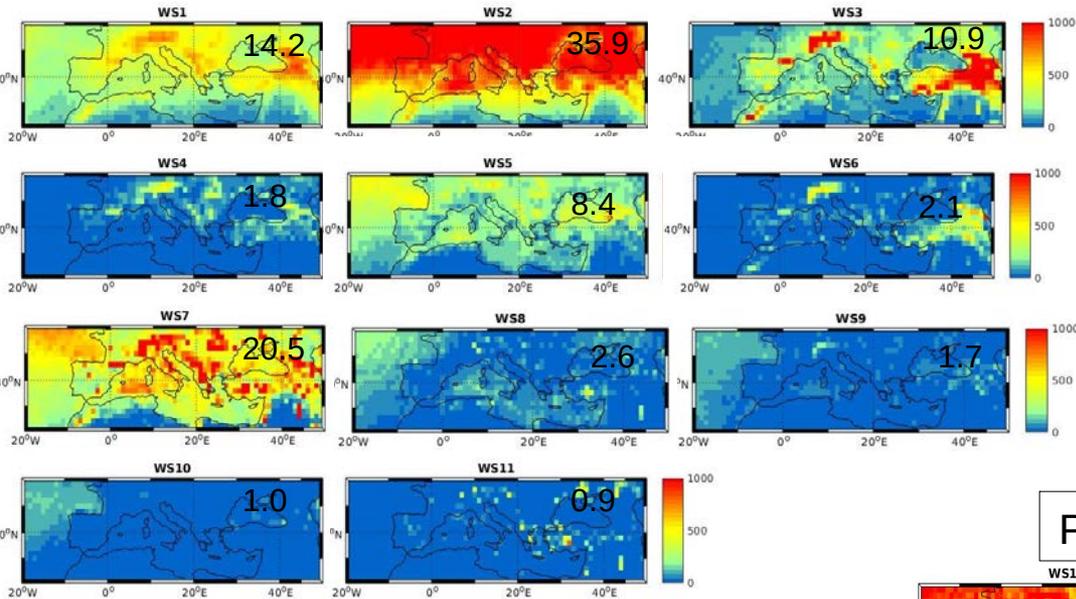
Mediterranean



- WS1 and WS2 : greater contribution to global precipitation (mostly heavy rain)
- WS2 the most frequent precipitation state over Mediterranean
- Rain also from thicker cirrus WS3cumulus congestus WS5, and most frequent fair weather WS7

# TRMM precipitation for the WSs over the Mediterranean

## Precipitation frequency

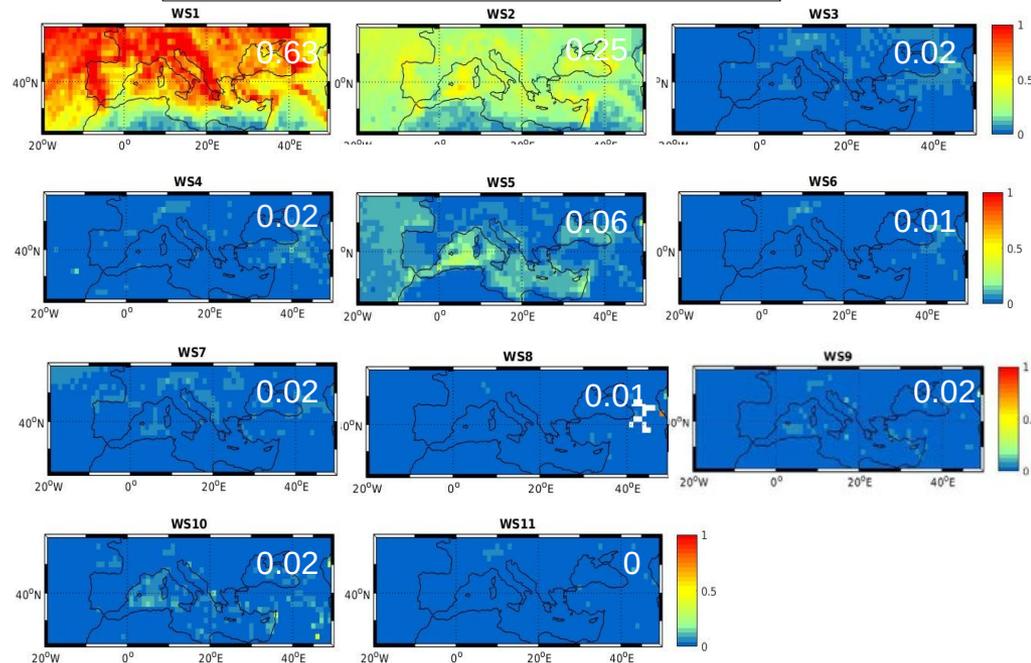


Precipitation frequency: WSs frequency + precipitation presence

-Dominant role of frontal WS2 in precipitation frequency

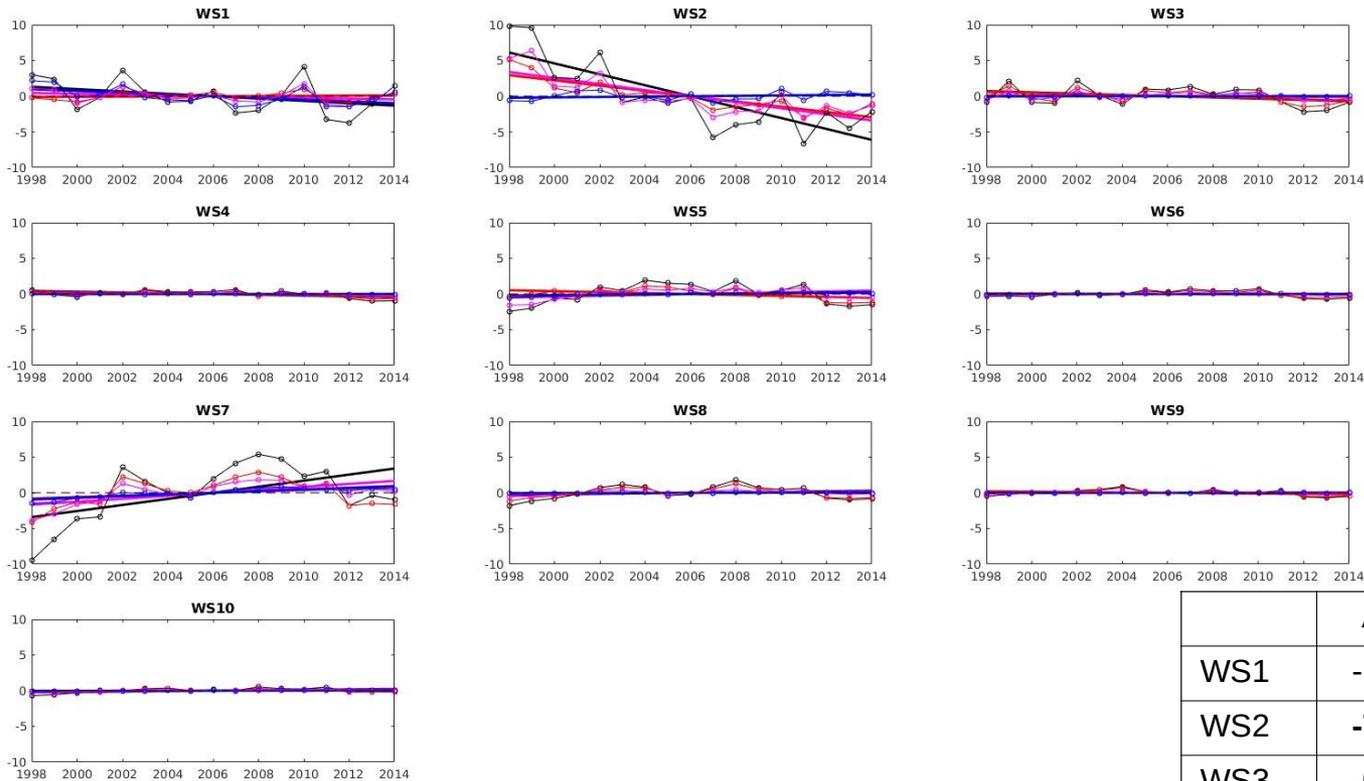
- Also contribution of WS1 and WS3 (mountain focus), WS5 (congestus) and WS7

## Precipitation intensity (mm/hr)



Precipitation intensity dominated by convective WS1 and storm WS2, with small contribution from congestus WS5

# Trends of TRMM frequency of precipitation over the Mediterranean



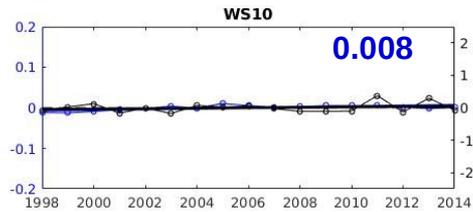
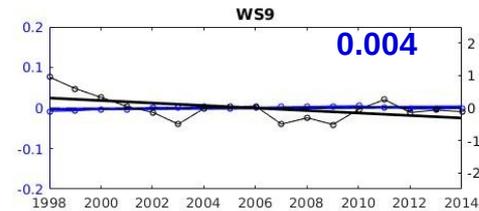
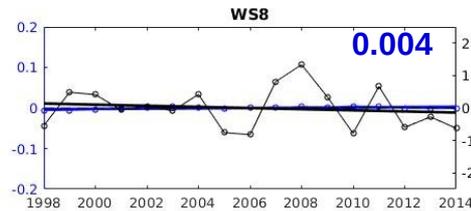
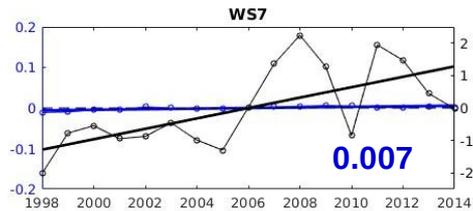
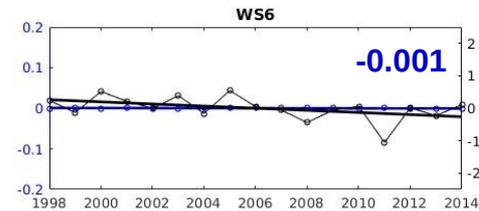
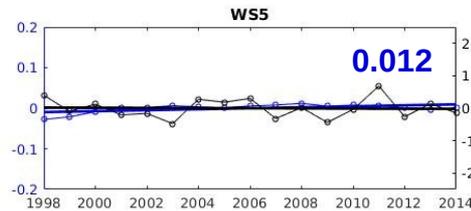
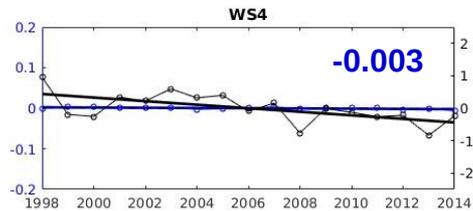
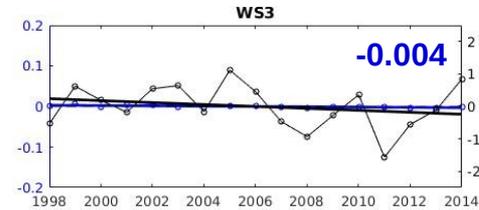
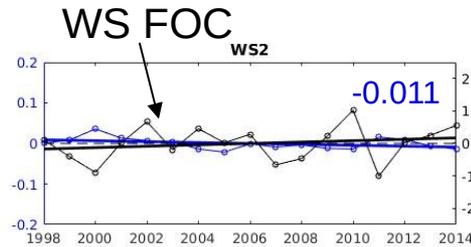
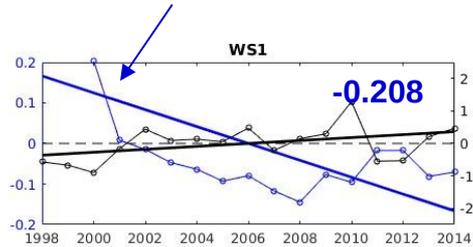
	All	Light	Moderate	Heavy
WS1	-1.7	0.1	-0.6	-1.2
WS2	<b>-7.7</b>	-3.7	-4.2	0.3
WS3	-0.9	-0.8	-0.1	0
WS4	<b>-0.5</b>	-0.4	-0.1	0
WS5	0.3	-0.7	0.6	0.3
WS6	0	-0.1	0	0
WS7	<b>4.3</b>	1.0	2.1	1.2
WS8	0.3	0.1	0.2	0.1
WS9	-0.2	-0.3	0	0
WS10	<b>0.3</b>	0.1	0.2	0

Strong decrease in precipitation frequency related to WS2 (mainly light and moderate)

⇒ decrease in total precipitation from decreased penetration of midlatitude storms

# Trends of TRMM Precipitation Intensity and ISCCP Global Weather States FOC over the Mediterranean

## Precipitation intensity



Decrease in convective precipitation due to strong decrease in intensity and heavy rain frequency  $\Rightarrow$  decrease in total precipitation

# Summary

- Global Weather States can be successfully applied to study precipitation mechanisms: comprehensive classification of precipitation into cloud regimes over the globe and the Mediterranean.
- Convective regimes are associated with heavy precipitation rates and produce the largest amounts of rainfall. Fair weather regimes produce small precipitation events and drizzle.
- Frontal WS2 is associated with the greatest number of precipitable events over the Mediterranean. The convective WS1 (despite its low frequency) is associated with greatest rainfall intensity.
- Significant decrease of frontal precipitation frequency (light and moderate) and convective precipitation intensity.
- The decrease of these two key weather states of precipitation are responsible for the overall decrease in precipitation over Mediterranean.