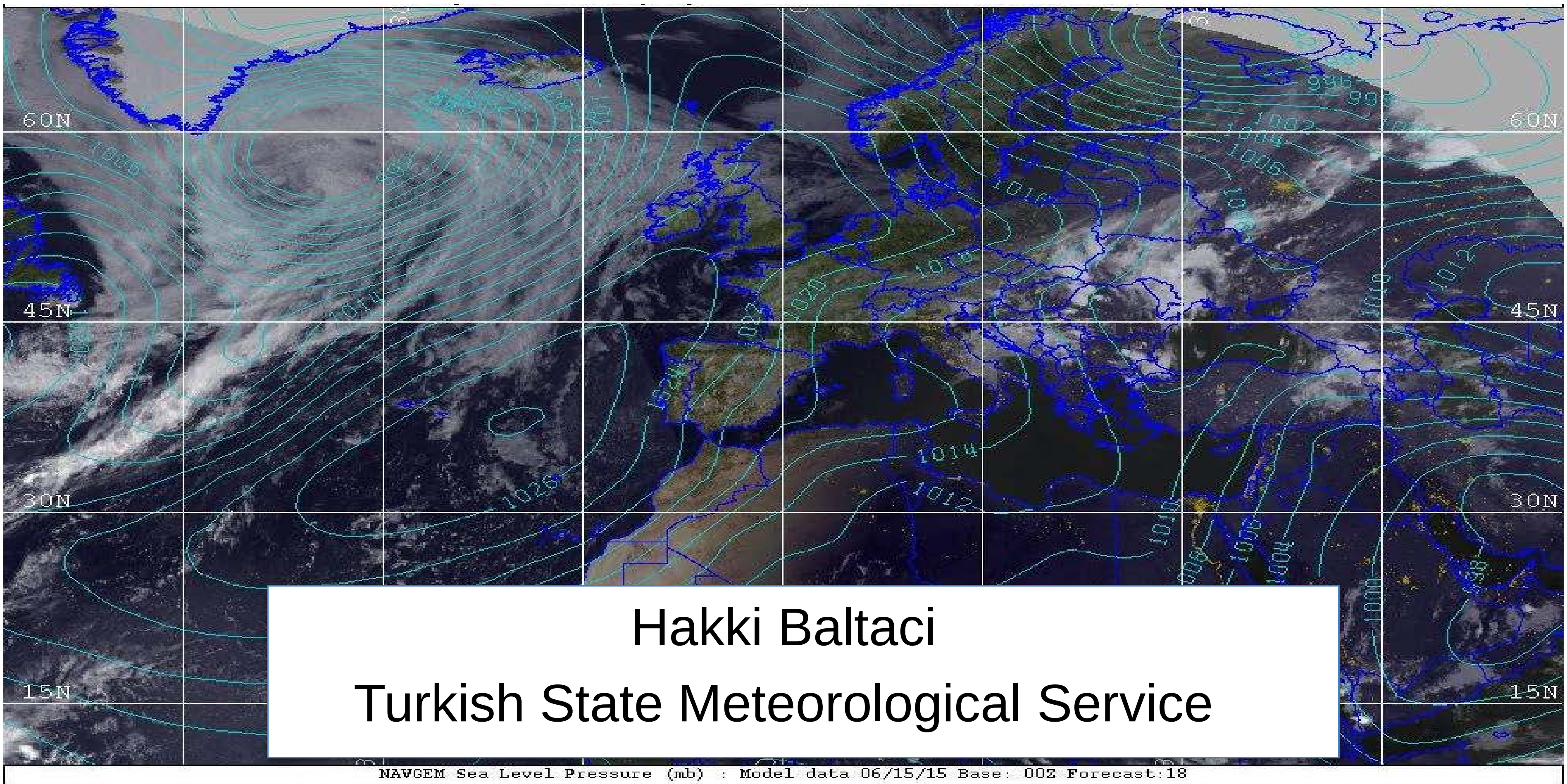
Temporal behavior of atmospheric circulation types in Marmara Region (NW Turkey)



Hakki Baltaci

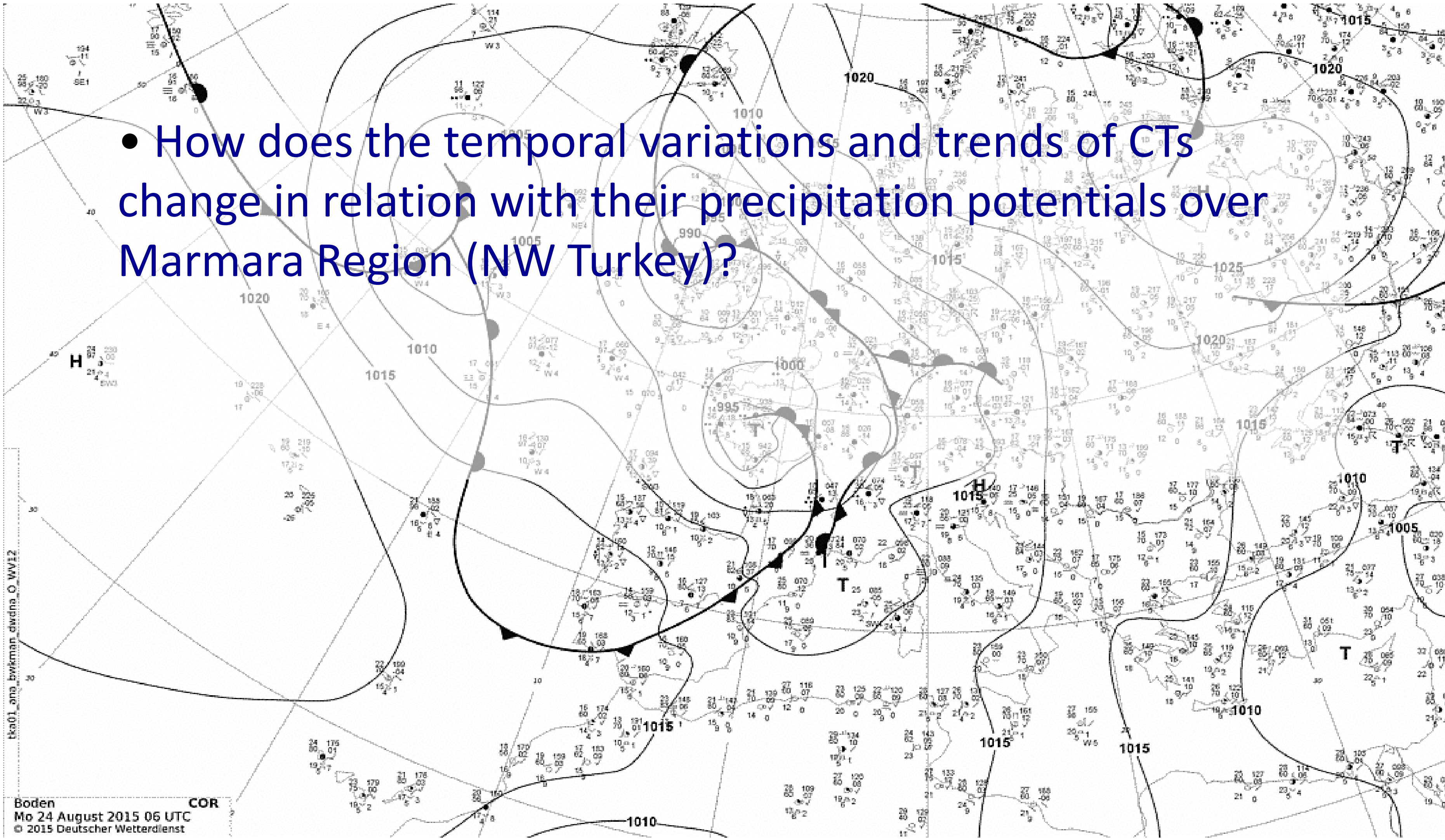
Turkish State Meteorological Service

Outline

- Introduction “Motivation and Purpose”
- Part-1: *Temporal behavior of atmospheric circulation types in Marmara Region (NW Turkey)*

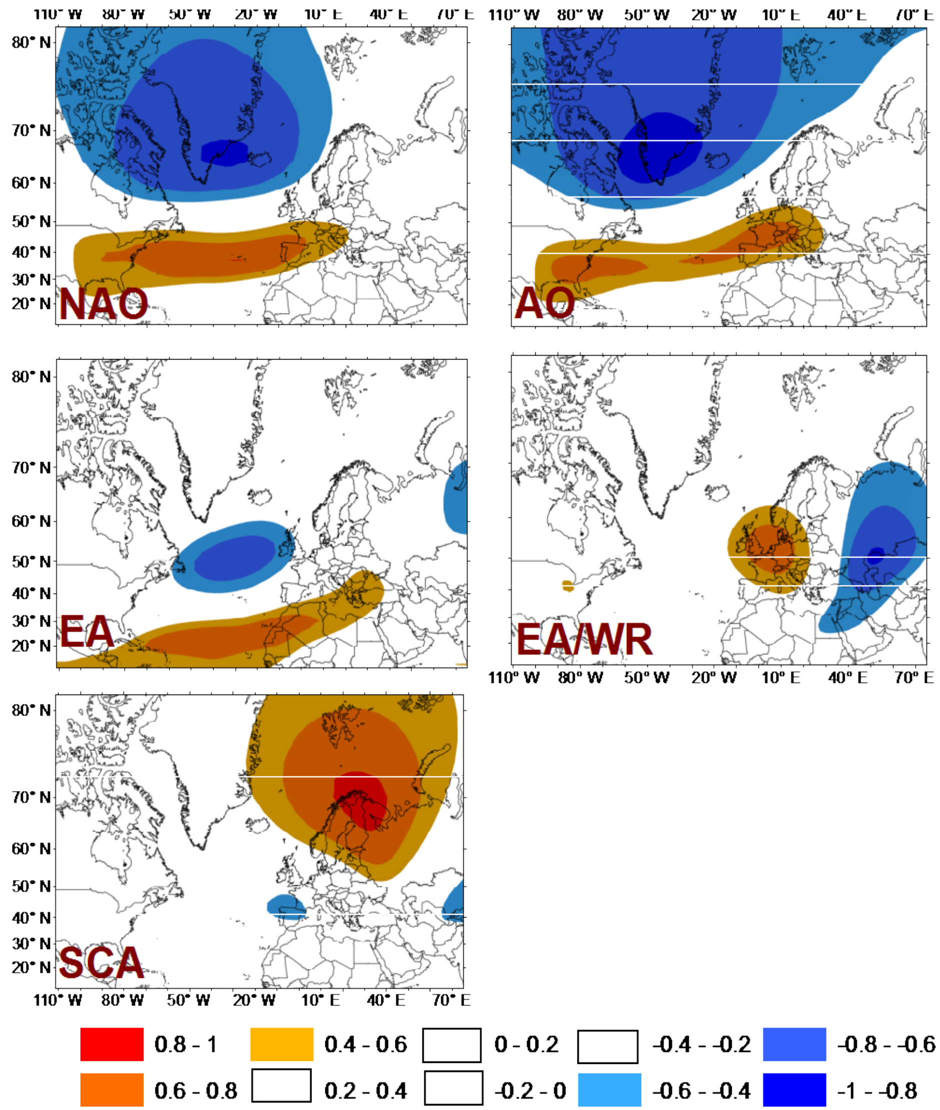
Research Question

- How does the temporal variations and trends of CTs change in relation with their precipitation potentials over Marmara Region (NW Turkey)?



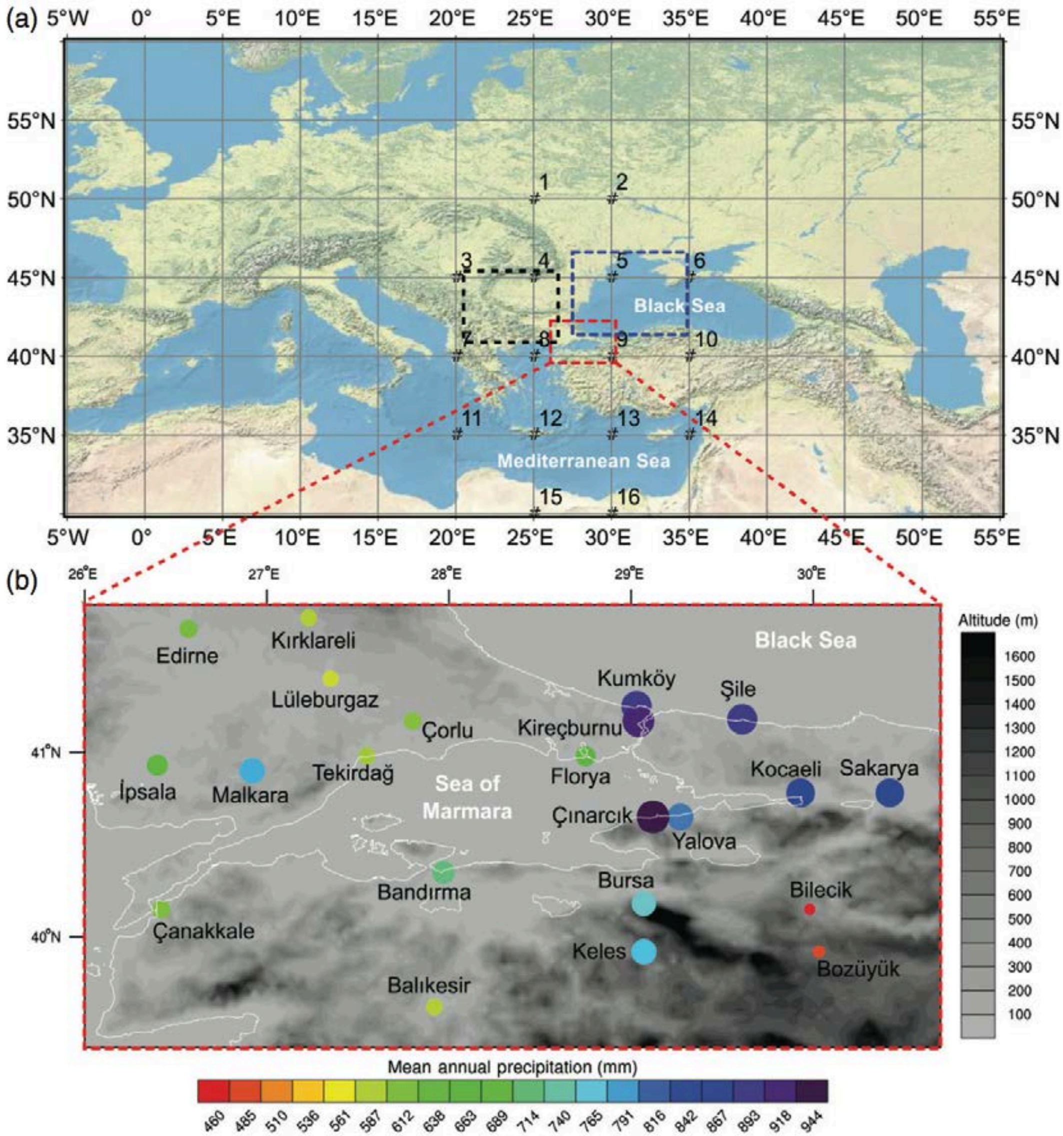
Research Area and Tools

- Marmara Region and prevailing precipitation characterstics
- Synoptic classification methods
  - Lamb Weather Type (LWT) methodology
- Teleconnection Patterns (NAO, AO, EA/WR, EA, SCA)



Baltacı et al., TAAC, 2018

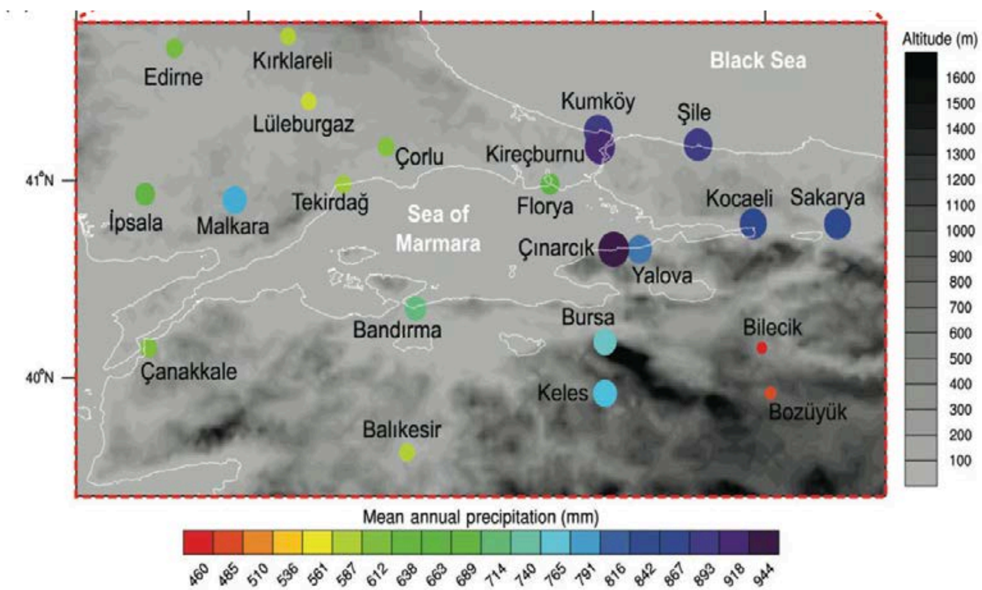
Precipitation climate of Marmara



- Most populated, agriculturally developed and populated geographical division in Turkey
- Continuous migration from other regions
- Increasing demand for water and also threating of existing water resources in the form of new and uncontrolled building activity (Deforestation)
- Sensitivity to climate change due to the added stressors of land-cover change and rapid urbanization

Baltacı et al., IJOC, 2015

Study area: Precipitation Climate

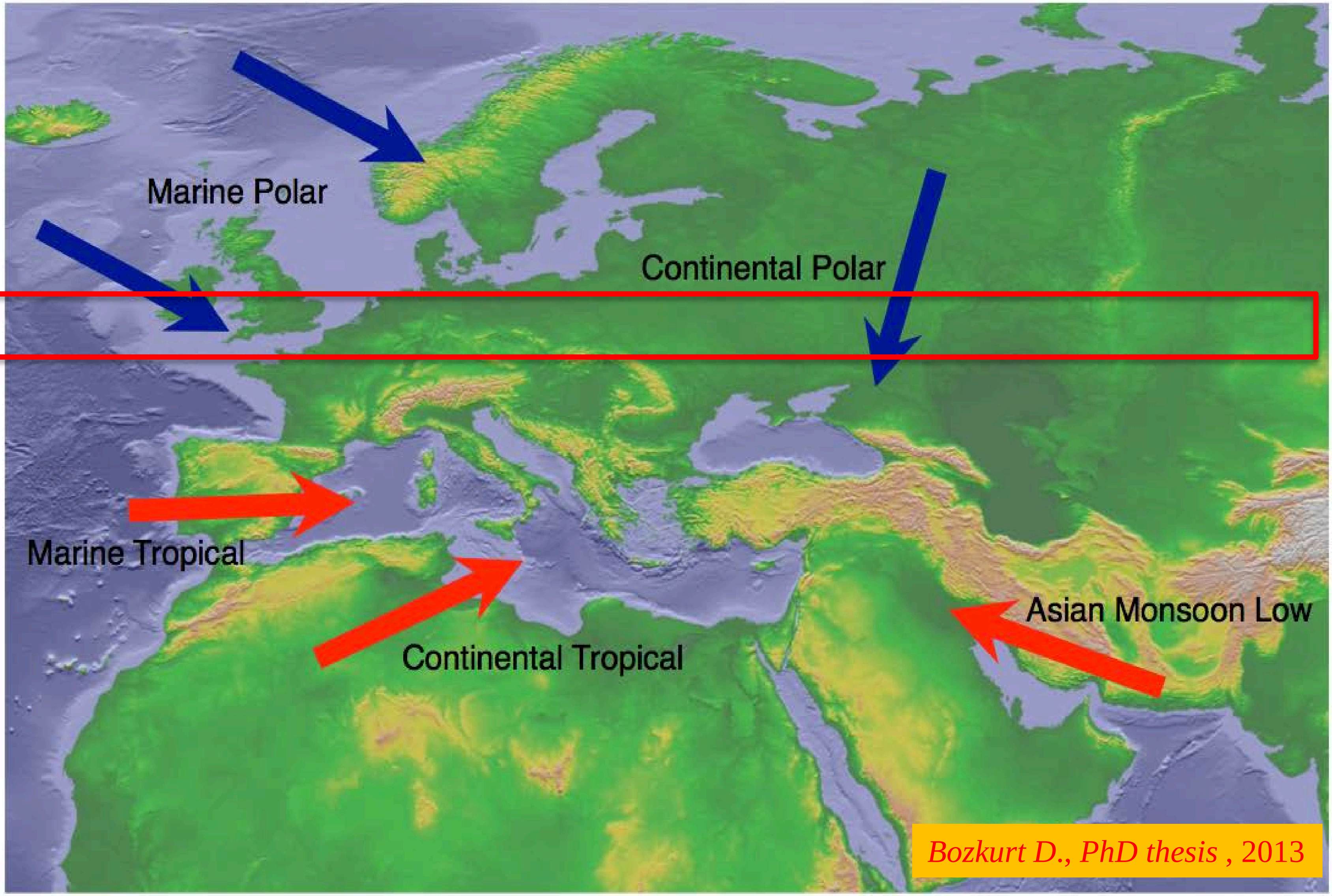


- Marmara Region is an area of transition between summer-dry Mediterranean and year-round-wet Black Sea precipitation regimes
- Inhomogeneous spatial distribution of rainfall (complex coastline and rugged topography)

- Stations located in the west and south part of the region exhibit Mediterranean type of annual precipitation distribution
- Stations in NE are remarkably wetter during summer months
- The area around Bilecik and interior part of the Thrace basin, which both have rain shadow character, have the lowest MAP values

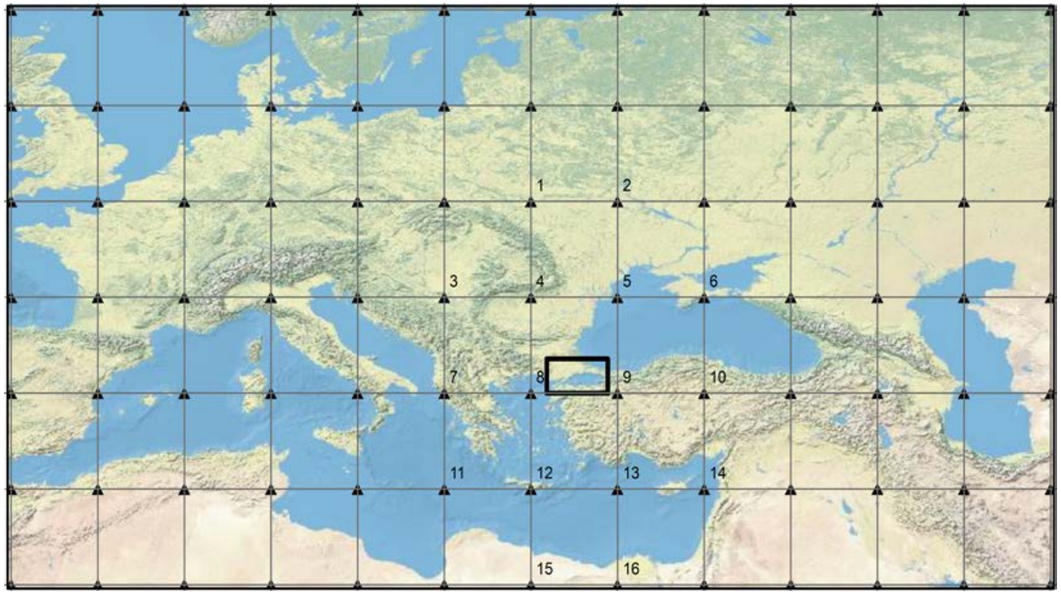
Baltacı et al., IJOC, 2015

1st research tool: Lamb Weather Type Methodology



Huth et al., Annals of the New York Academy of Sciences , 2008

1st research tool: Lamb Weather Type Methodology



Grid numbers which have used in the study

$$WF = \left[\frac{1}{2}(p_{12}+p_{13}) - \frac{1}{2}(p_4+p_5)\right] \quad (1)$$

$$SF = 1.305\left[\frac{1}{4}(p_5+2^*p_9+p_{13}) - \frac{1}{4}(p_4+2^*p_8+p_{12})\right] \quad (2)$$

$$FF = (WF^2+SF^2)^{0.5} \quad (3)$$

$$WSV = 1.12^*\left[\frac{1}{2}(p_{15}+p_{16}) - \frac{1}{2}(p_8+p_9)\right] - 0.91^*\left[\frac{1}{2}(p_8+p_9) - \frac{1}{2}(p_1+p_2)\right] \quad (4)$$

$$SSV = 0.85^*\left[\frac{1}{4}(p_6+2^*p_{10}+p_{14}) - \frac{1}{4}(p_5+2^*p_9+p_{13}) - \frac{1}{4}(p_4+2^*p_8+p_{12}) + \frac{1}{4}(p_3+2^*p_7+p_{11})\right] \quad (5)$$

$$Z = WSV + SSV \quad (6)$$

LWTs methodology

Pure Types	Directional Types	Hybrid Types	
U	N	CN	AN
C	NE	CNE	ANE
A	E	CE	AE
	SE	CSE	ASE
	S	CS	AS
	SW	CSW	ASW
	W	CW	AW
	NW	CNW	ANW

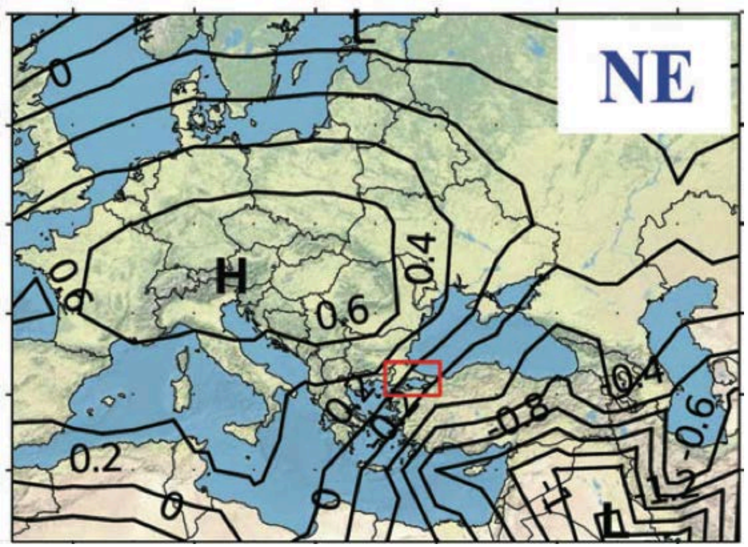
D=arctan(SW/WF) if WF<0

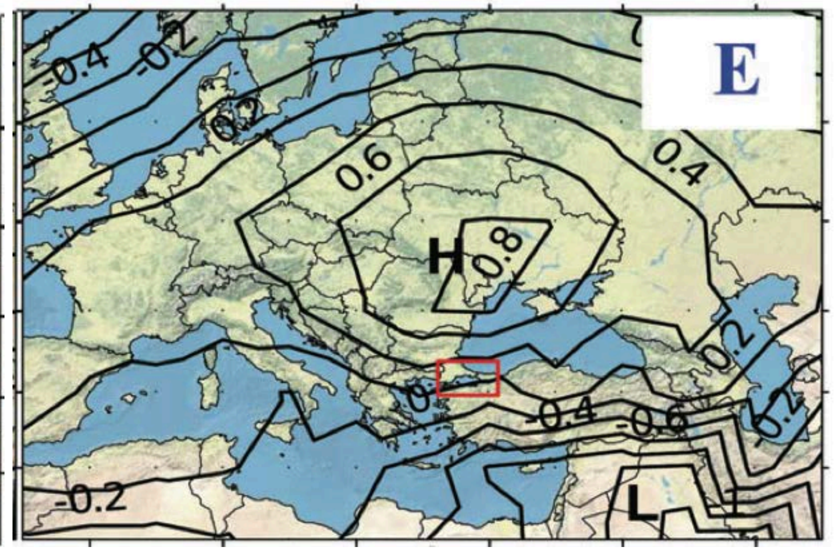
D=arctan(SW/WF)+180 if WF>0

Visualization of CTs (26 + 1)

Baltacı et al., IJOC, 2015

Analysis of atmospheric CTs



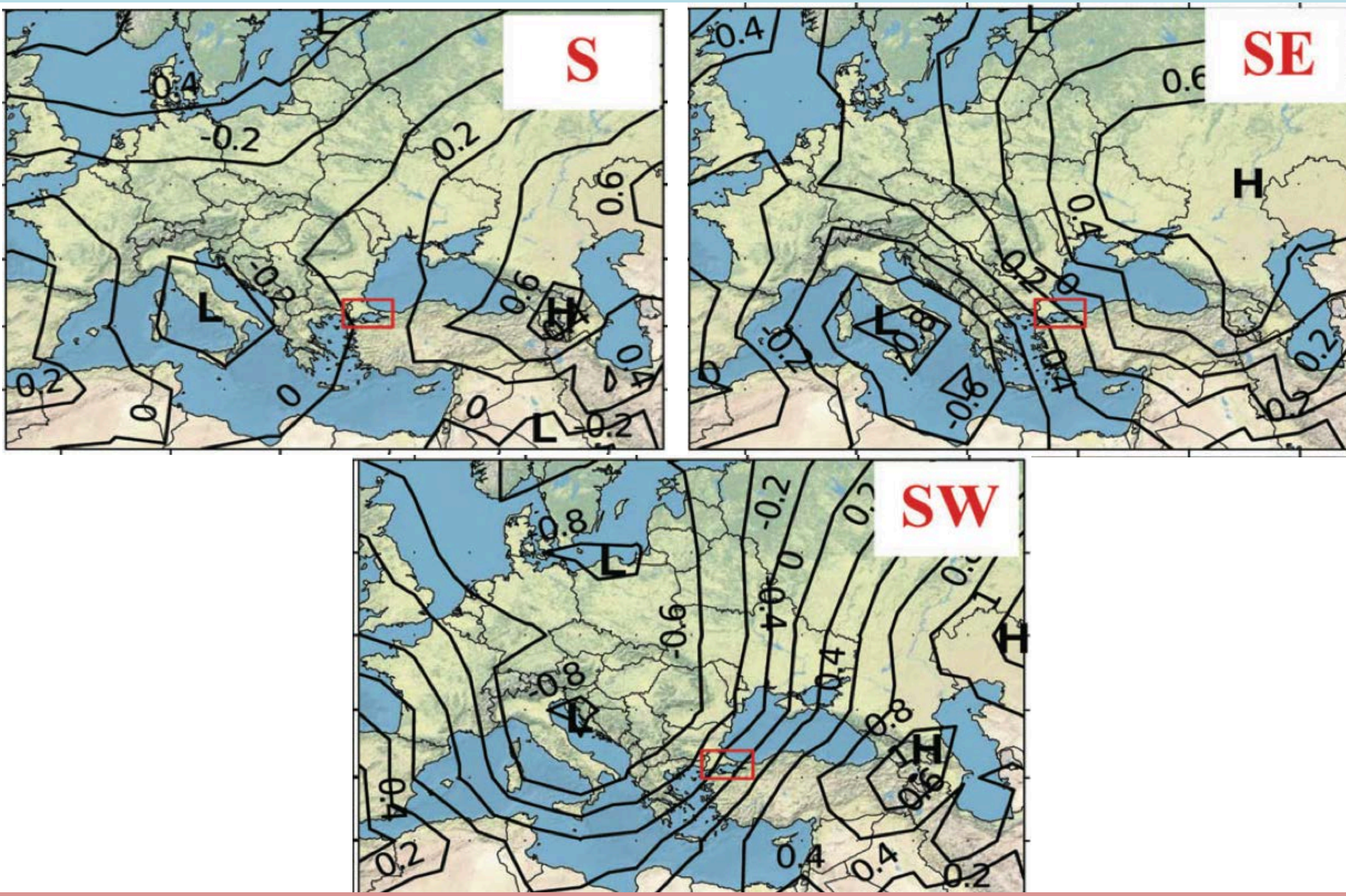


Synoptic features are a prominent blocking high over Eastern Europe and a low centred in the Middle East.

Accordingly, at least slightly positive MSLP anomalies are observed at the northern half of the Mediterranean basin along with Marmara Region; while MSLP over eastern Mediterranean Sea exhibits negative anomalies

Baltacı et al., IJOC, 2015

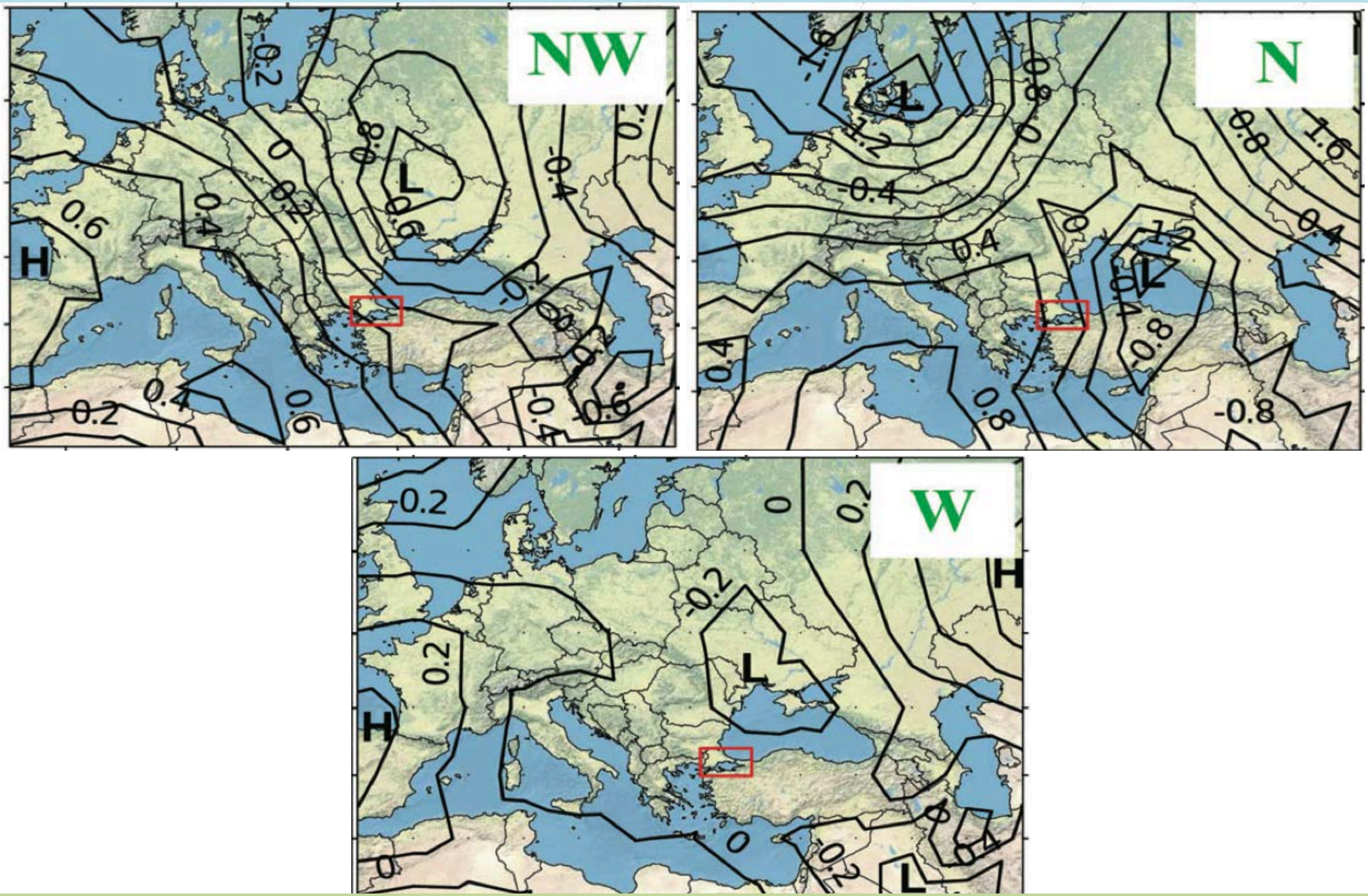
Analysis of atmospheric CTs



All of southerly types have a low around Italy. MSLP around the Central Mediterranean and Aegean Seas take on negative anomaly values. It is again slightly negative in the region Marmara, except for S pattern.

Baltacı et al., IJOC, 2015

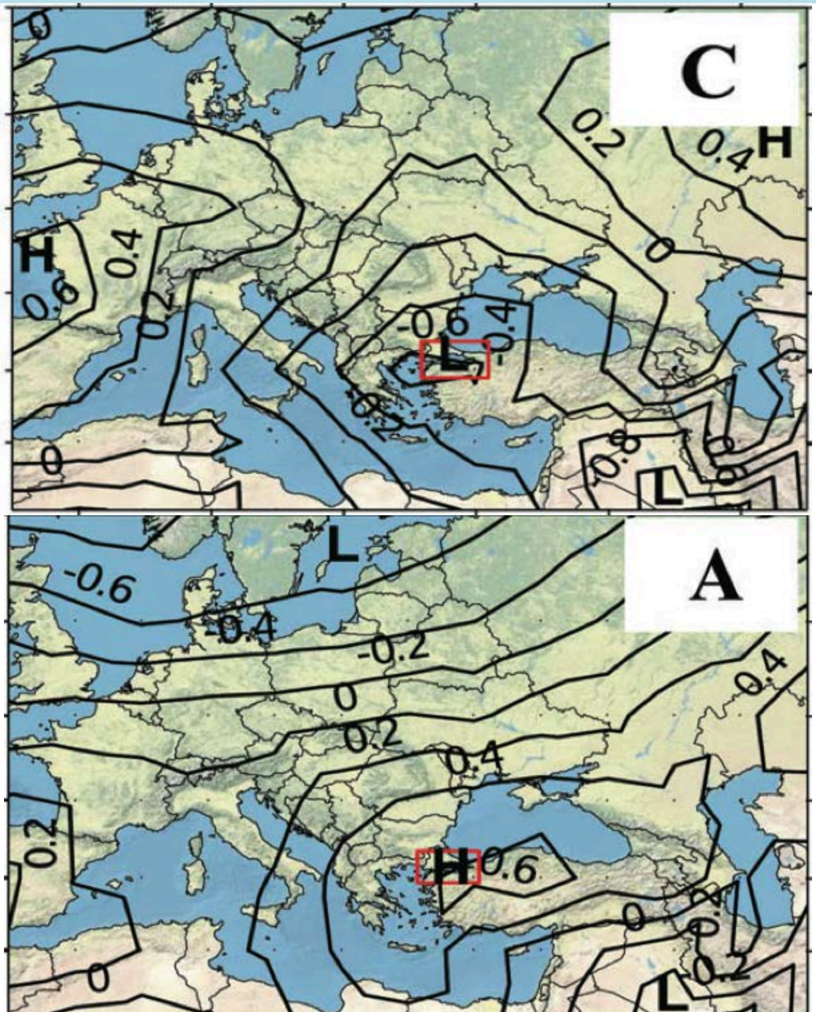
Analysis of atmospheric CTs



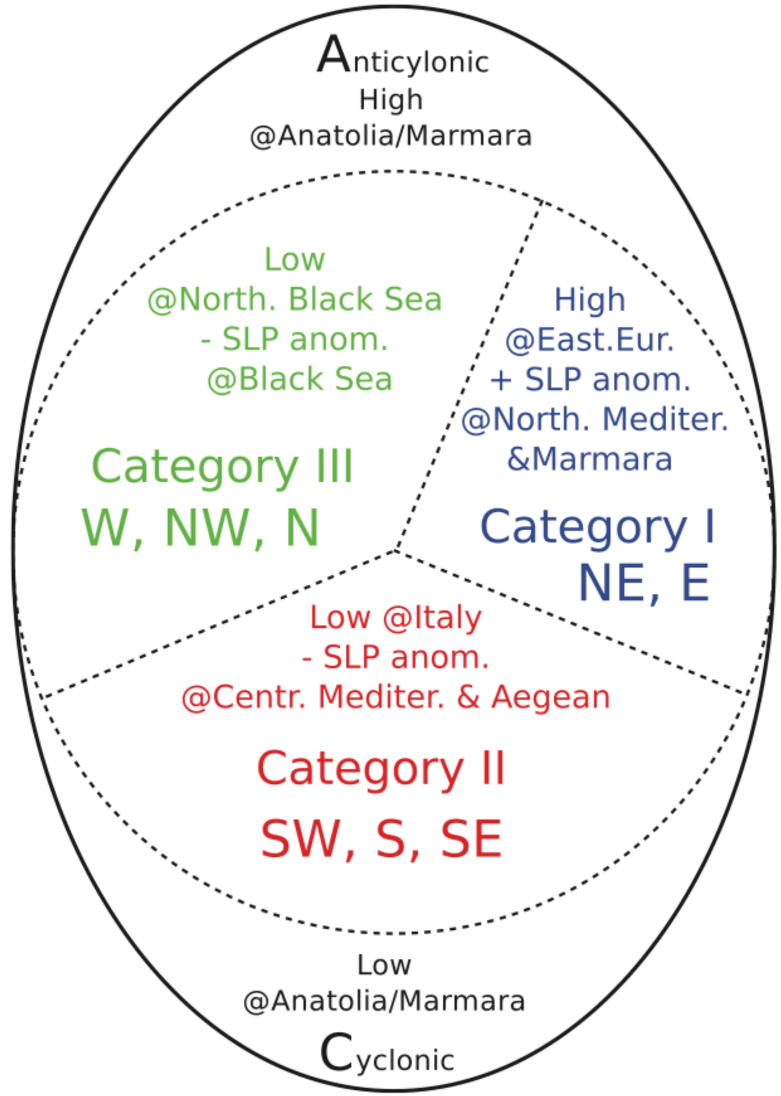
A low is observed around the northern edge of the Black Sea. This configuration leads to negative MSLP anomalies over the Black Sea and the Marmara Region, except for N pattern

Baltacı et al., IJOC, 2015

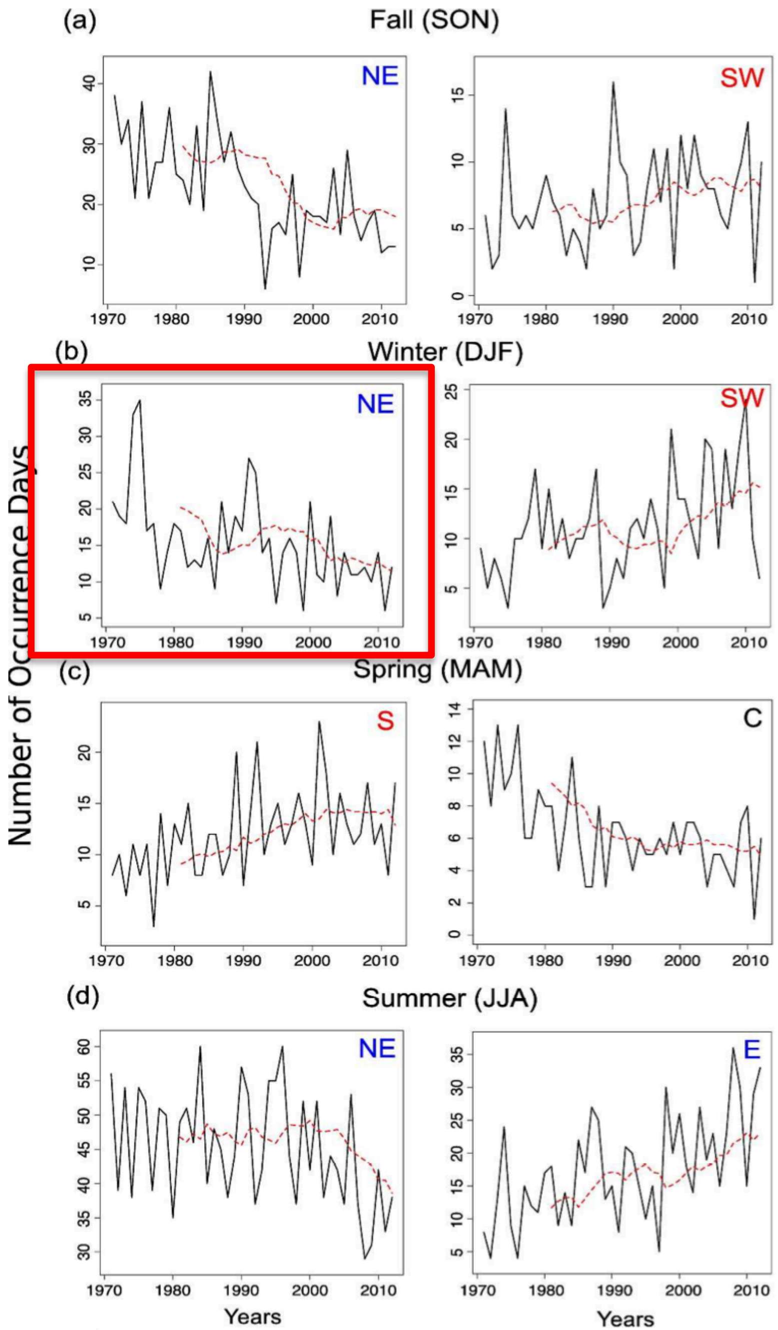
Analysis of atmospheric CTs



Cyclonic and Anticyclonic patterns, where a low and high are located, respectively, very close to the region of Marmara



Baltacı et al., IJOC, 2015



Circulation Type	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
N	**-2.31**	-0.13	**-2.41**	-1.66
NE	**-3.39**	-1.31	**-2.61**	**-4.85**
E	0.63	0.46	**3.85**	1.77
SE	1.78	-0.10	-0.30	1.80
S	0.18	**2.75**	0.84	1.11
SW	**2.61**	0.32	-0.44	**2.04**
W	0.01	-0.02	-0.77	0.81
NW	-1.57	-0.04	-1.54	-1.05
C	-0.15	**-3.56**	-0.63	-0.33
A	1.74	0.70	-0.28	**2.41**

Table I. Mann-Kendall test statistics for the trends in occurrence frequencies of each circulation pattern (CT) influencing Marmara Region during the period 1971-2012 (bold numbers denote statistically significant trends at 0.95 level).

Circulation Type	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
N	0.62	0.65	-1.27	1.37
NE	**3.32**	1.04	-0.48	**3.68**
E	1.65	0.70	-0.41	0.86
SE	1.27	-0.96	**3.97**	1.13
S	0.40	-0.16	-0.39	-1.34
SW	0.79	1.00	**2.53**	-0.01
W	0.28	0.23	0.52	1.45
NW	1.53	-0.47	0.46	1.62
C	1.14	-0.15	-0.35	1.19
A	0.37	0.91	1.05	0.67

Table II. Mann-Kendall test statistics for the trends of regionally averaged rainfall potentials (mm/day) of each circulation pattern (CT) influencing Marmara Region during the period 1971-2012 (bold numbers denote statistically significant trends at 0.95 level).

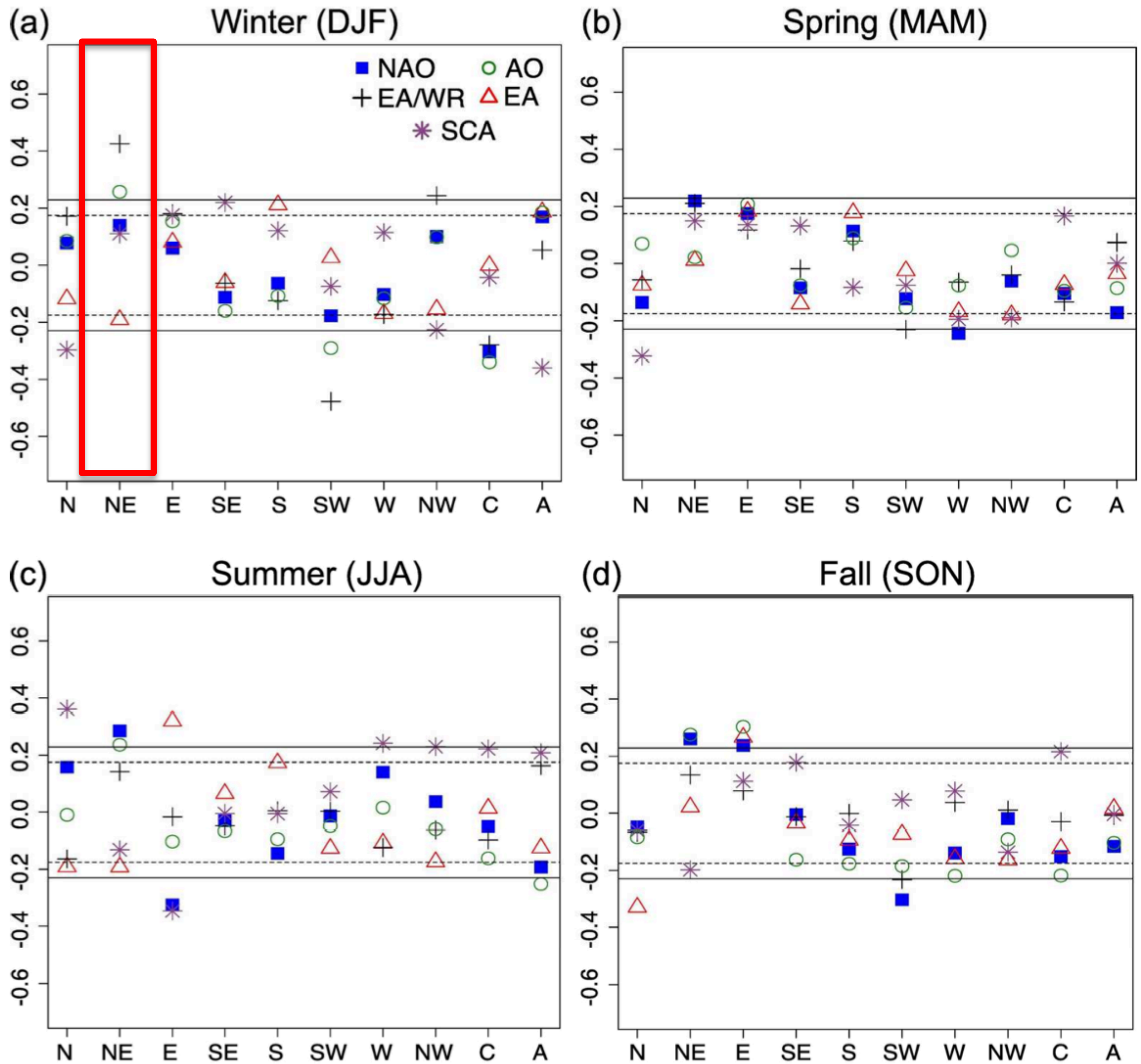


Figure 3. Pearson's correlation coefficients between mean seasonal teleconnection pattern indices and the seasonal number of occurrence days of each circulation type for the Marmara Region, for the period 1971-2012. Each panel is for a different season. Statistically significant correlation values at the 99% and %95 levels are the ones which are greater than the absolute values denoted by the solid and dashed lines, respectively.

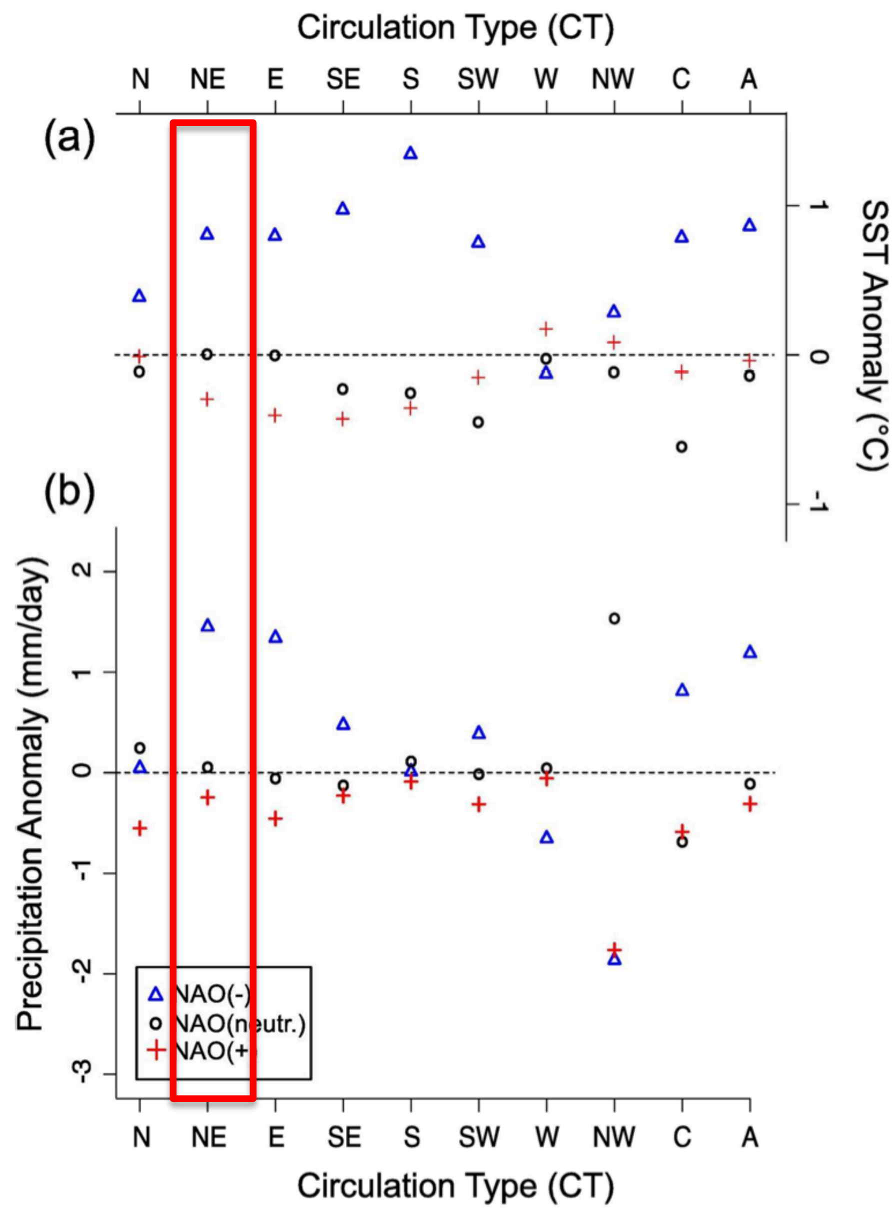


Figure 4. Responses of each circulation type during winter (DJF) to the different phases of the North Atlantic Oscillation, in terms of a) sea surface temperatures and b) regionally averaged precipitation potential.

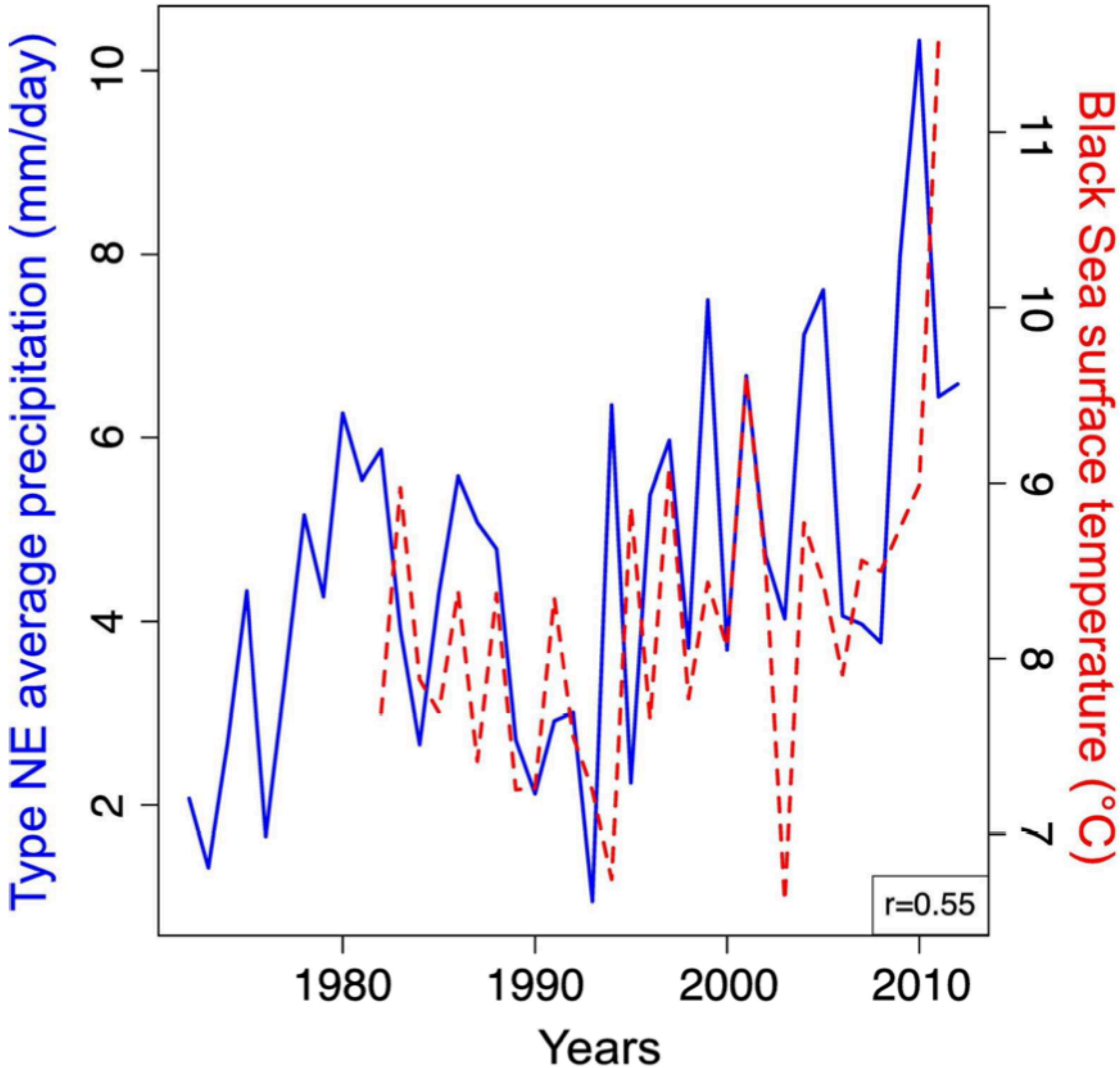
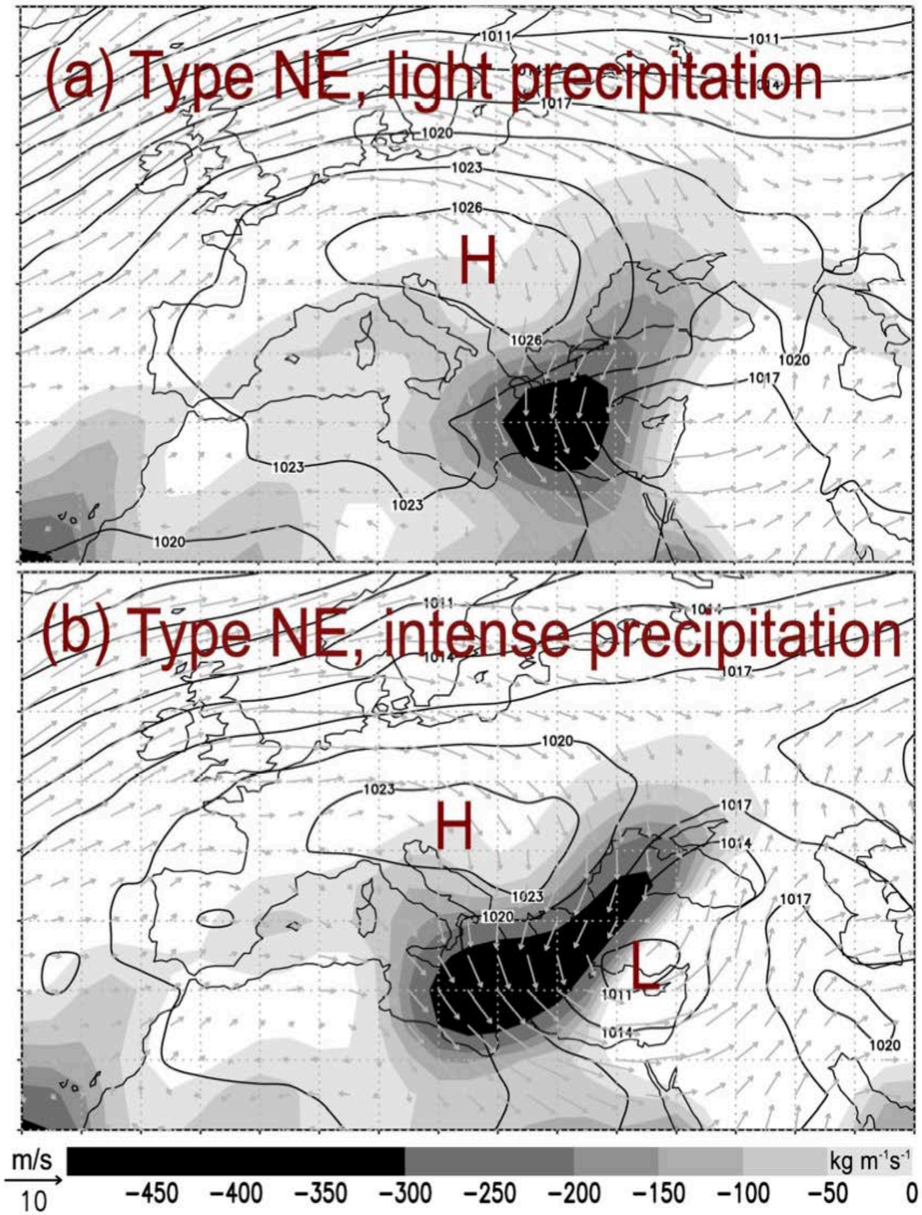


Figure 6. DJF (winter) variations of the regionally averaged precipitation amount associated with the northeasterly (NE) circulation type (solid blue line), along with the Black Sea surface temperatures; within the period 1981-2012. "r" stands for the Pearson's correlation coefficient between the two.



$$Q_v = \frac{1}{g}\int_{pt}^{po} qv\,dp$$

$$Q_u = \frac{1}{g}\int_{pt}^{po} qu\,dp$$

where Q_v is the meridional moisture flux, Q_u is the zonal moisture flux, g is the gravity, q is the specific humidity, u and v are the zonal and meridional components of the wind, and pt and po represent the pressure at 300 hPa and the surface, respectively. Vertically integrated meridional moisture flux was calculated from the Q_v equation for each grid point using finite differences from surface to the 300-hPa (surface, 1000, 925, 850, 700, 600, 500, 400 and 300 hPa levels).

Results

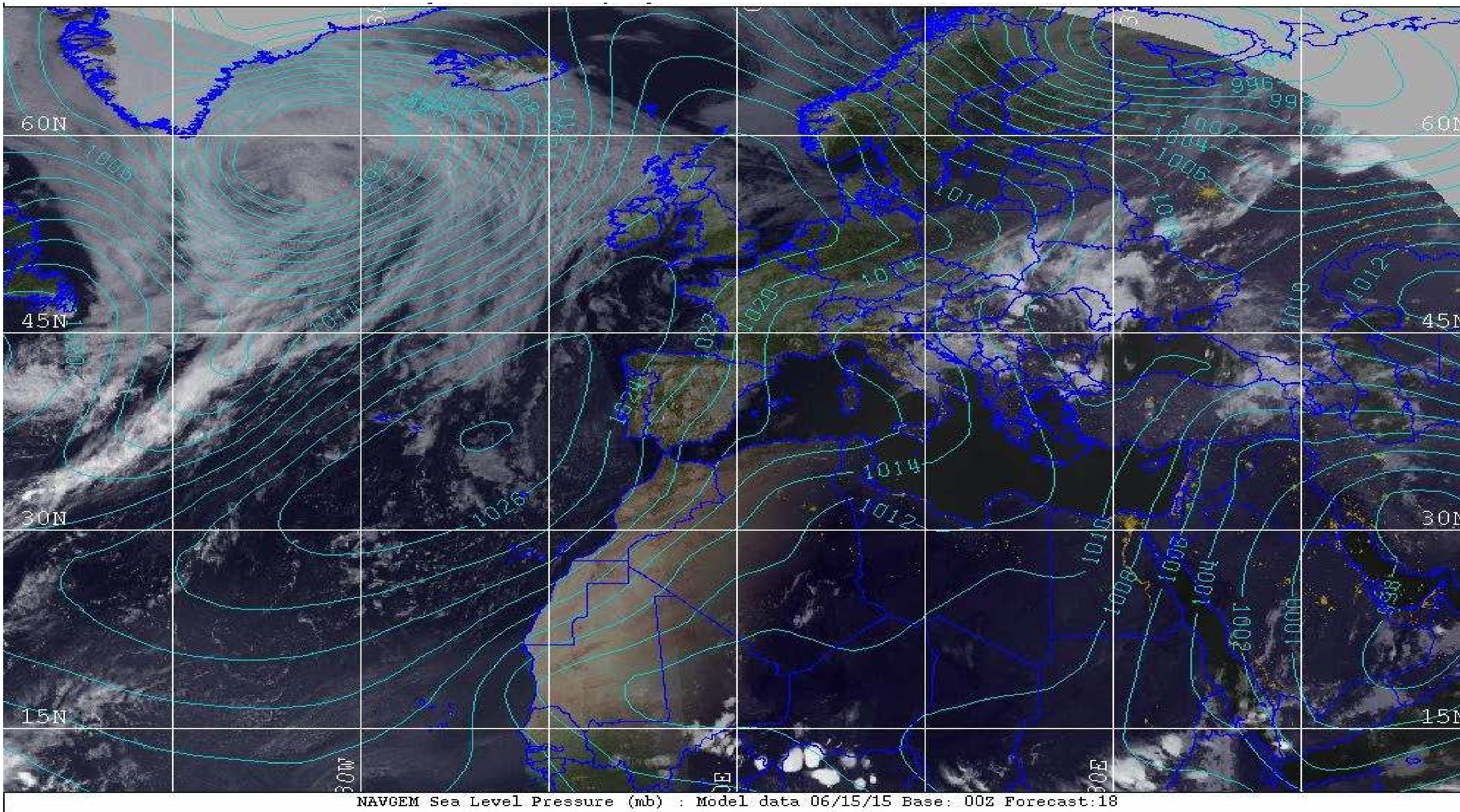
- In DJF (wettest season in Marmara Region), the frequency of occurrence of the northeasterly (NE) CT was declining.

- Contrary to its declining frequency of occurrence, regionally averaged precipitation amount of type NE in DJF is on the rise. This increase in NE's precipitation potential is mainly because of the enhanced moisture availability due to the increasing SSTs of the Black Sea, which is a clear response to regional warming trend.

- A slight trend in the DJF EA/WR index towards more negative values might be playing a role too, as type NE is wetter in DJF when it coincides with the negative phase of the EA/WR, AO, and the NAO.

- Probable continuation of these trends in the future means an increasing intensity of individual precipitation events (i.e. floods and heavy snow) along with a decreasing number of wet days, especially in the eastern parts of the region including Istanbul, where type NE is the main supplier of rainfall.

Thank You



60N
45N
30N
15N
30W
30E
1014
1012
1026
NAVGEM Sea Level Pressure (mb) : Model data 06/15/15 Base: 00Z Forecast:18