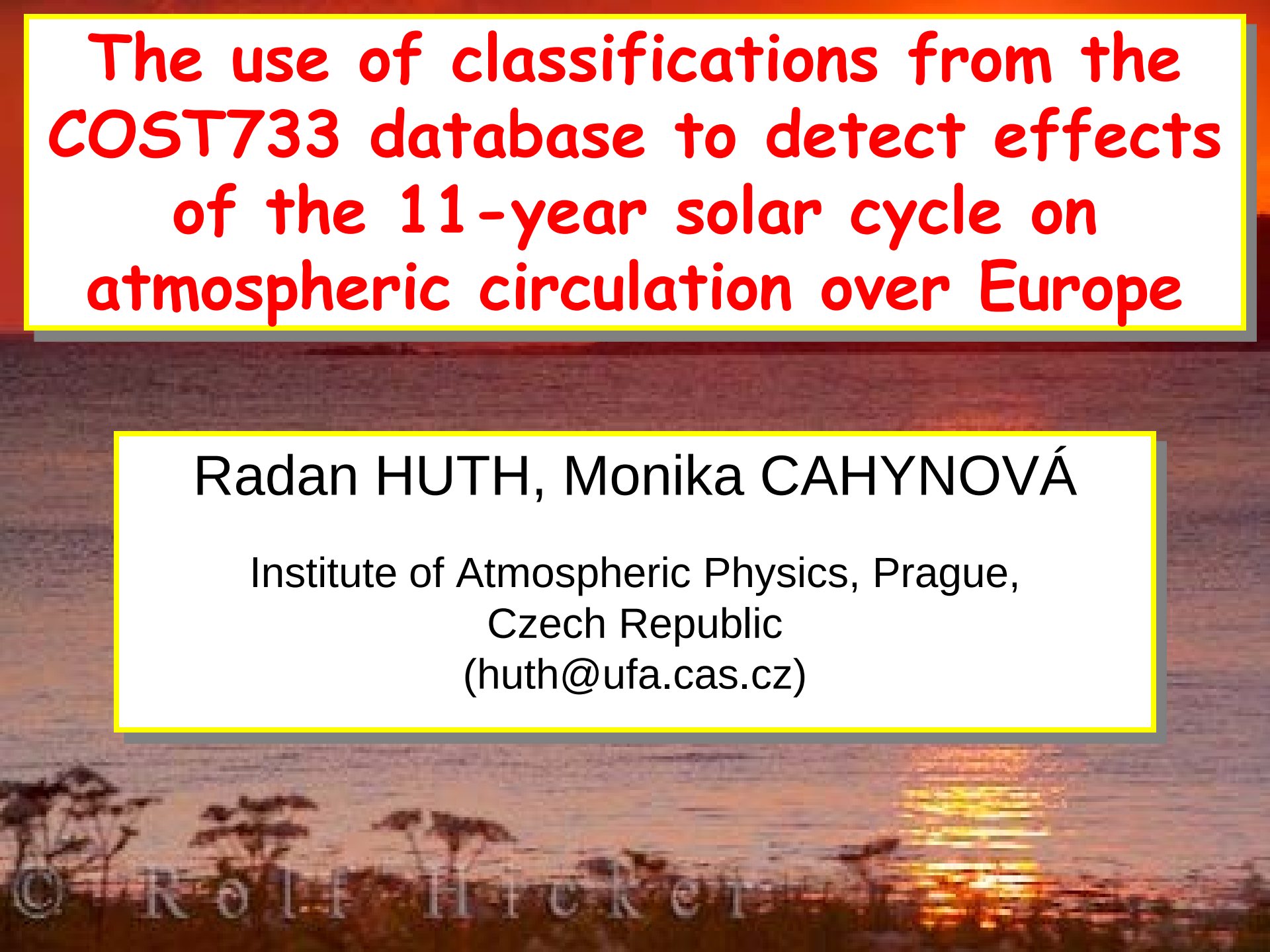
The use of classifications from the COST733 database to detect effects of the 11-year solar cycle on atmospheric circulation over Europe

Radan HUTH, Monika CAHYNOVÁ

Institute of Atmospheric Physics, Prague,
Czech Republic
(huth@ufa.cas.cz)



- Wolf numbers (R) (~numbers of sunspots)
- solar radio flux 10.7 cm (F10.7)
- (the choice of variable has only a minor effect on results)

mechanisms?

- modes of low-frequency variability
- Arctic Oscillation
- teleconnectivity
- blocking activity
- cyclonic activity
- circulation effects on surface climate
- frequency of synoptic types

Mechanisms of the effects Sun→Earth

- several potential mechanisms
- so far unclear, which of them are really acting and how much they contribute
- a new COST Action on it

Potential mechanisms

- stratospheric ozone: change in UV radiation ➔ O_3 concentration ➔ stratospheric temperature ➔ stratospheric circulation ➔ downward propagation of the signal to the troposphere
- change of currents in the global electric circuit ➔ atmospheric circulation
- changes in concentrations of particles of cosmic origin ➔ condensation nuclei ➔ clouds
- direct heating of ocean surface ➔ feedbacks with cloudiness ➔ atmospheric circulation

Data & Methods

- monthly mean values
- extended winter (XII – III)
- 1961 – 2000 (1949-2003 for Hess&Brezowsky)
- main methodological concept: division of data according to the solar activity into three groups (low, medium, high)
- separate analysis in each solar activity class

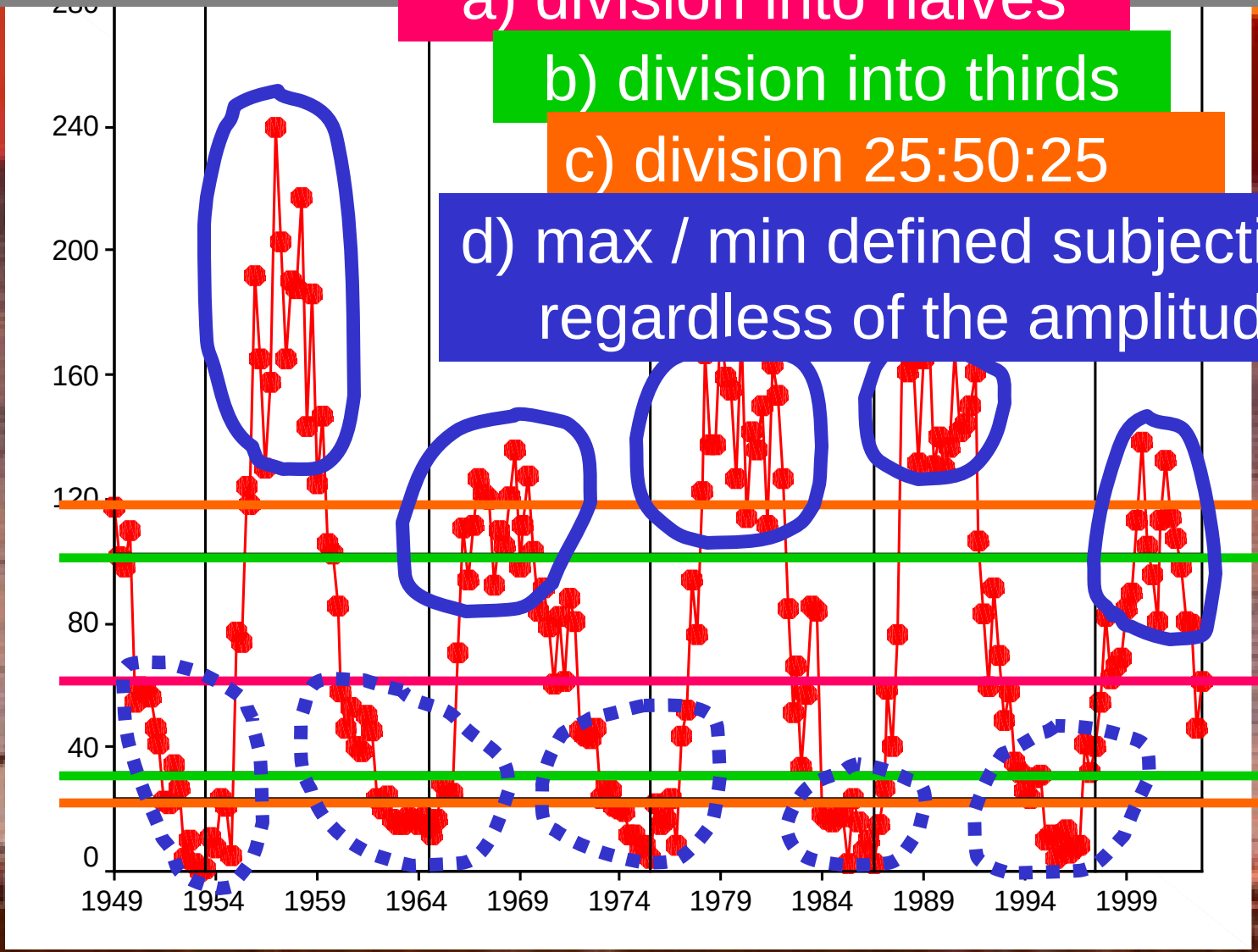
Solar activity classes

a) division into halves

b) division into thirds

c) division 25:50:25

d) max / min defined subjectively regardless of the amplitude



SYNOPTIC TYPES

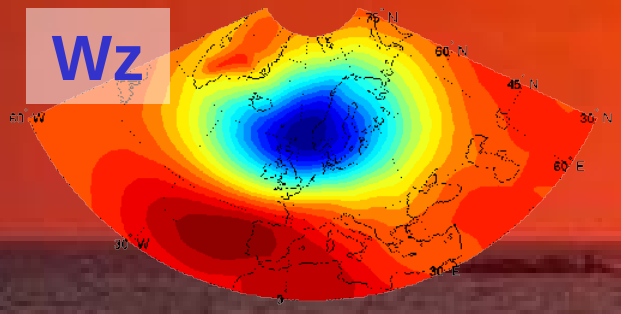
- after Hess&Brezowsky
  - grouped into 10 ‘major types’ and 6 ‘supertypes’
  - mean SLP anomaly maps
- from COST733 database v2.0
  - for SLP
  - have 11 types or fewer
  - for domain D07 (central Europe)
  - SANDRA and SOM are identical ➔ only SANDRA is retained
  - altogether 17 class’s
  - types are characterized by mean anomaly maps (centroids) for 500 hPa heights

METHODOLOGY

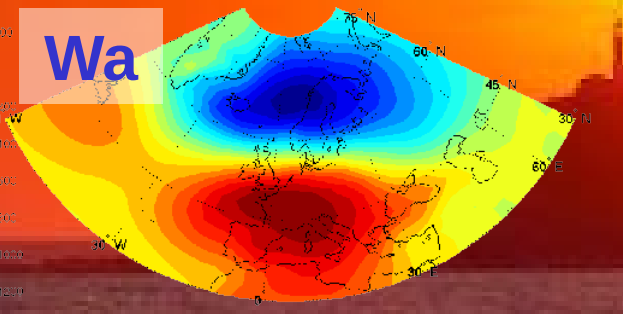
- what's calculated:
  - mean frequencies of types (supertypes)
  - for each solar activity class
- statistical significance testing
  - is the frequency in the given solar activity class different from the (long-term) mean frequency of the type?
  - using block resampling

westerly

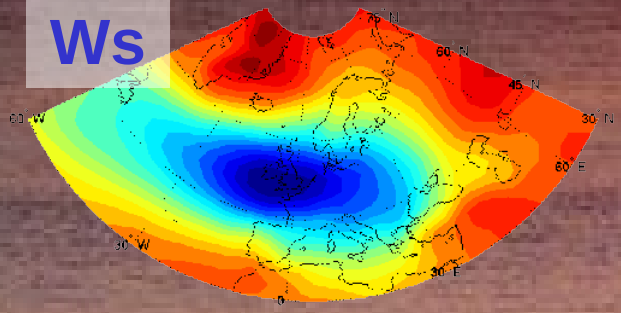
Wz



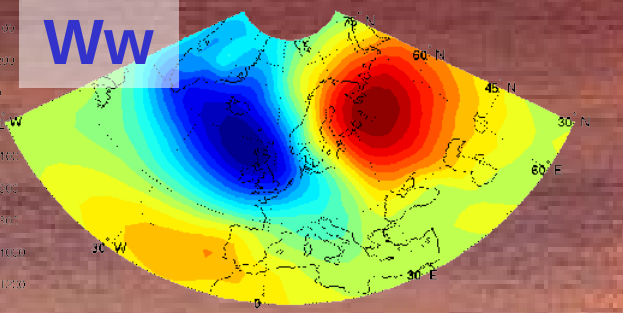
Wa



Ws



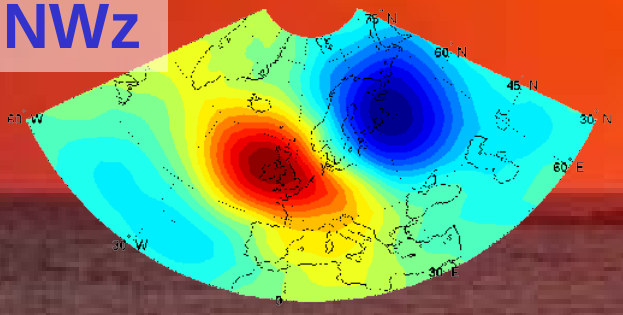
Ww



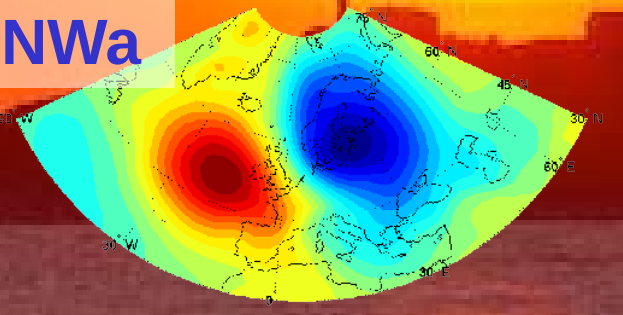
	low	medium	high
solar	26,2	31,6	33,7

northwesterly

NWz



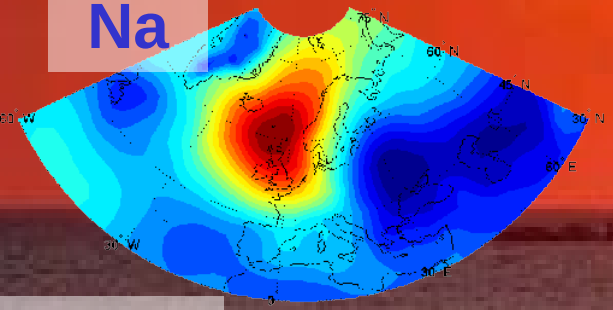
NWa



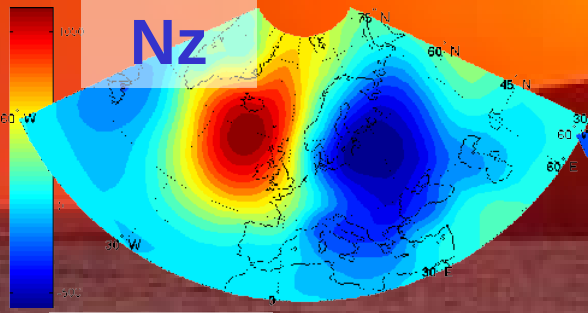
	low	medium	high
solar	6,9	10,0	6,7

northerly

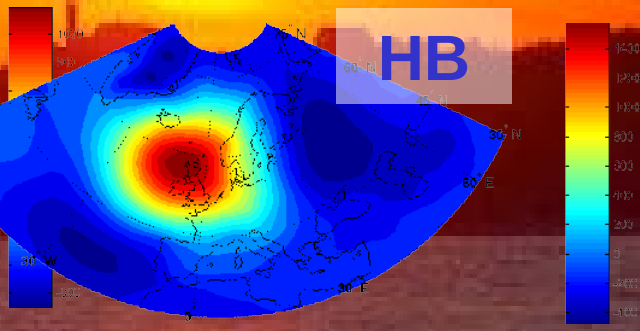
Na



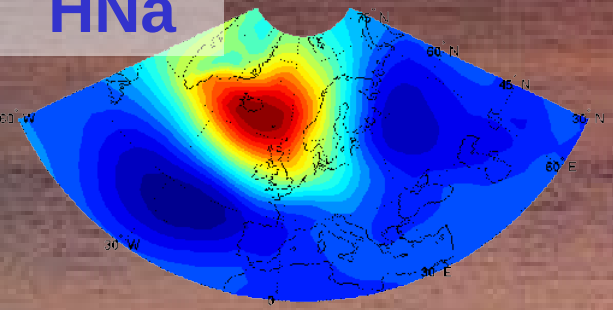
Nz



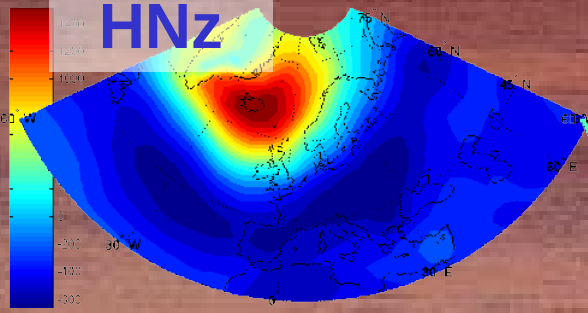
HB



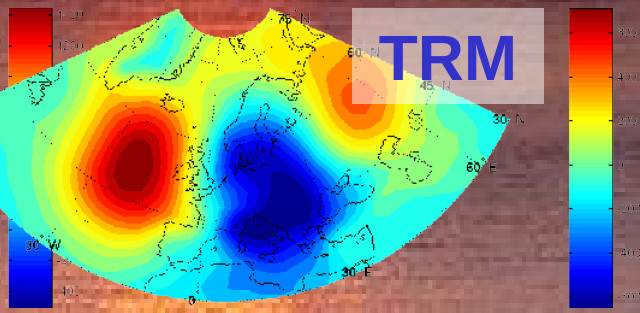
HNa



HNz



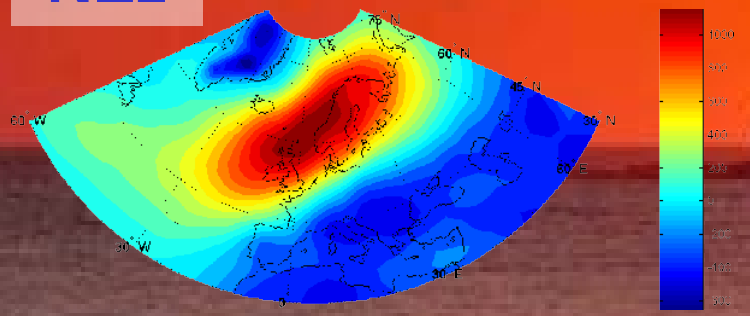
TRM



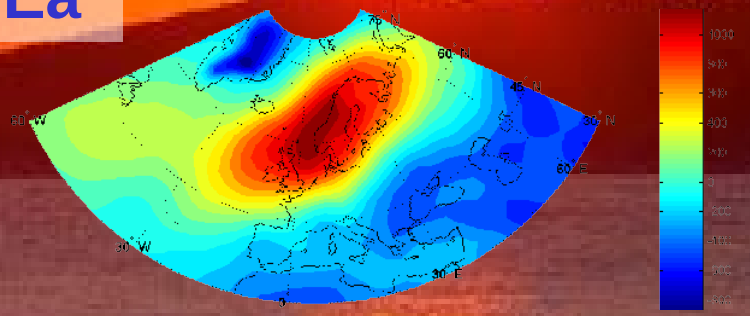
	low	medium	high
solar	17,9	13,0	11,0

northeasterly

NEz



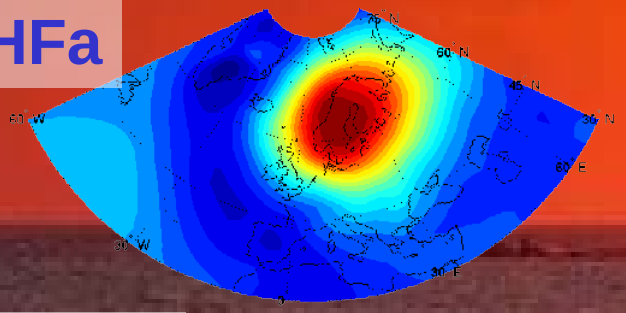
NEa



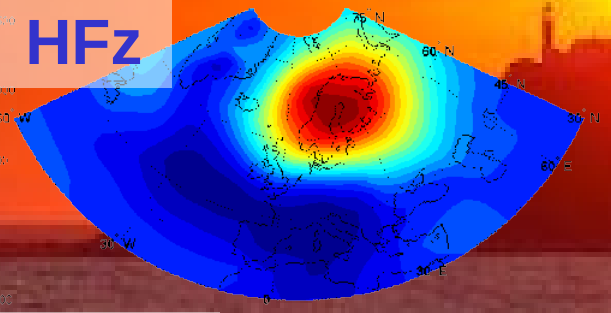
	low	medium	high
solar	2,0	2,4	1,6

easterly

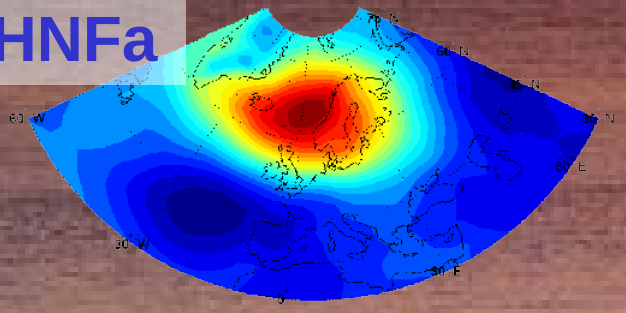
HFa



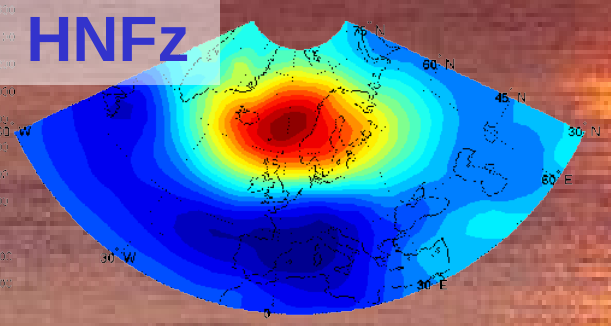
HFz



HNFa



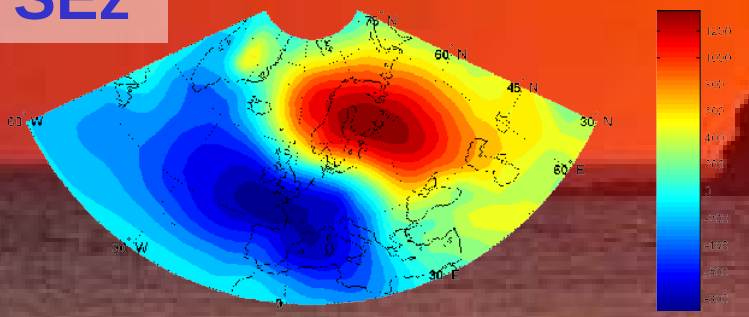
HNFz



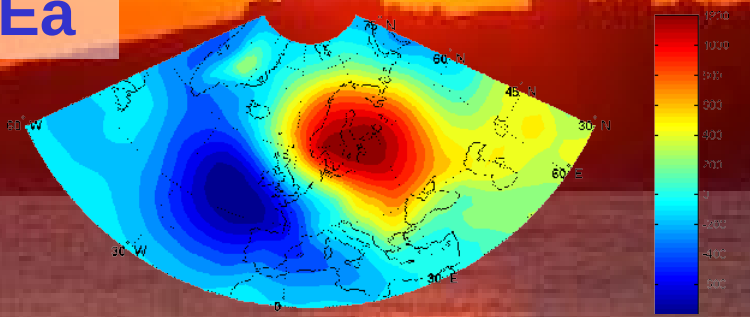
	low	medium	high
solar	12,9	6,0	9,1

southeasterly

SEz



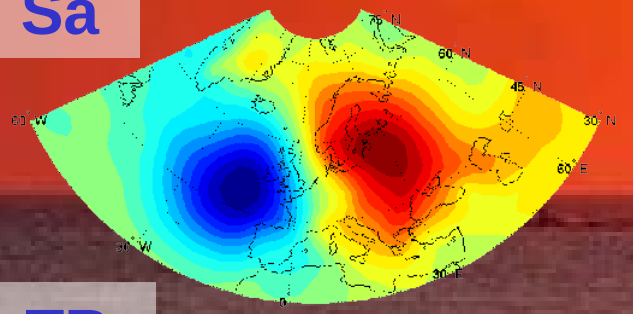
SEa



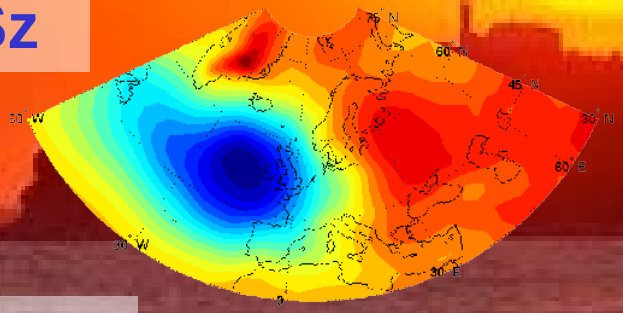
	low	medium	high
solar	5,4	4,3	5,9

southerly

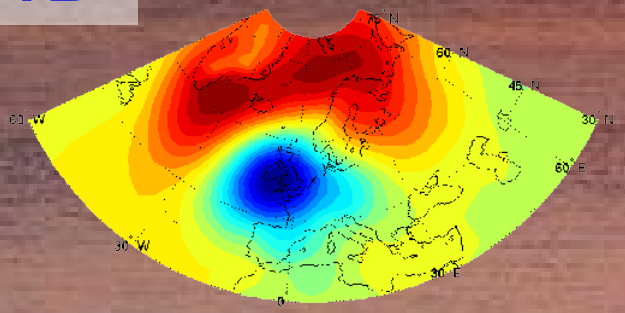
Sa



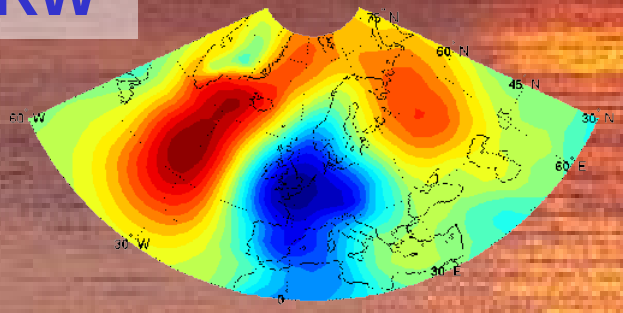
Sz



TB



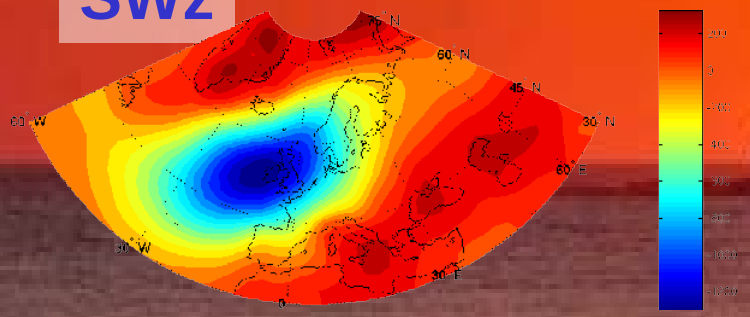
TRW



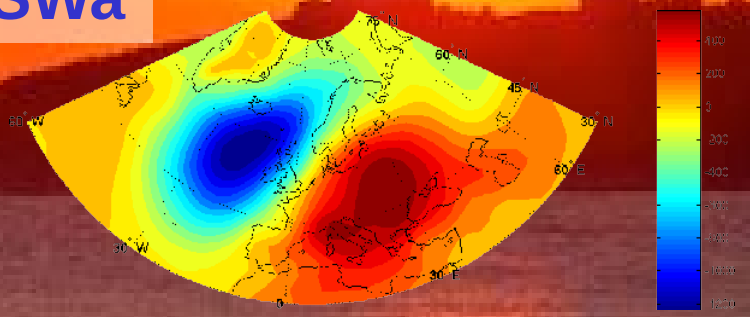
	low	medium	high
solar	6,9	6,5	5,8

southwesterly

SWz



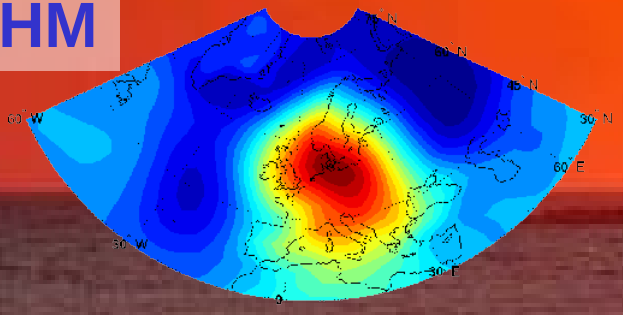
SWa



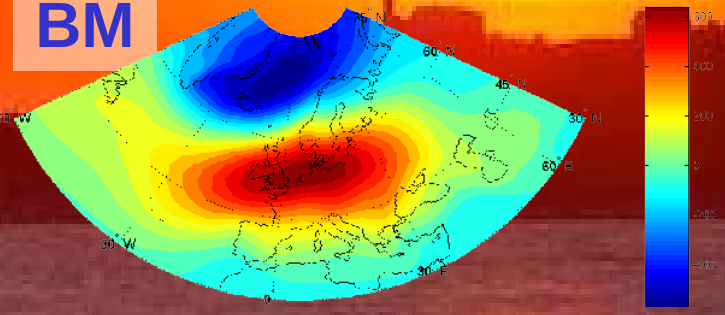
	low	medium	high
solar	6,4	7,8	6,8

central European high

HM



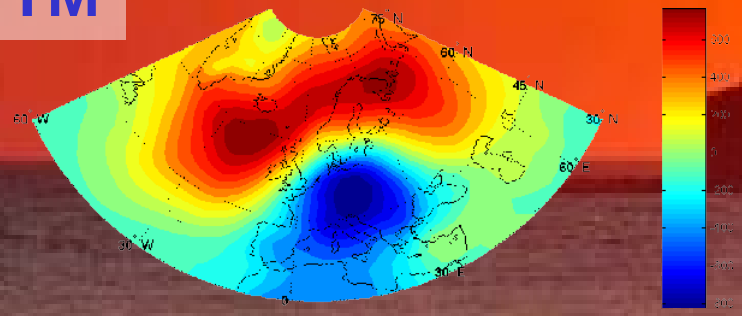
BM



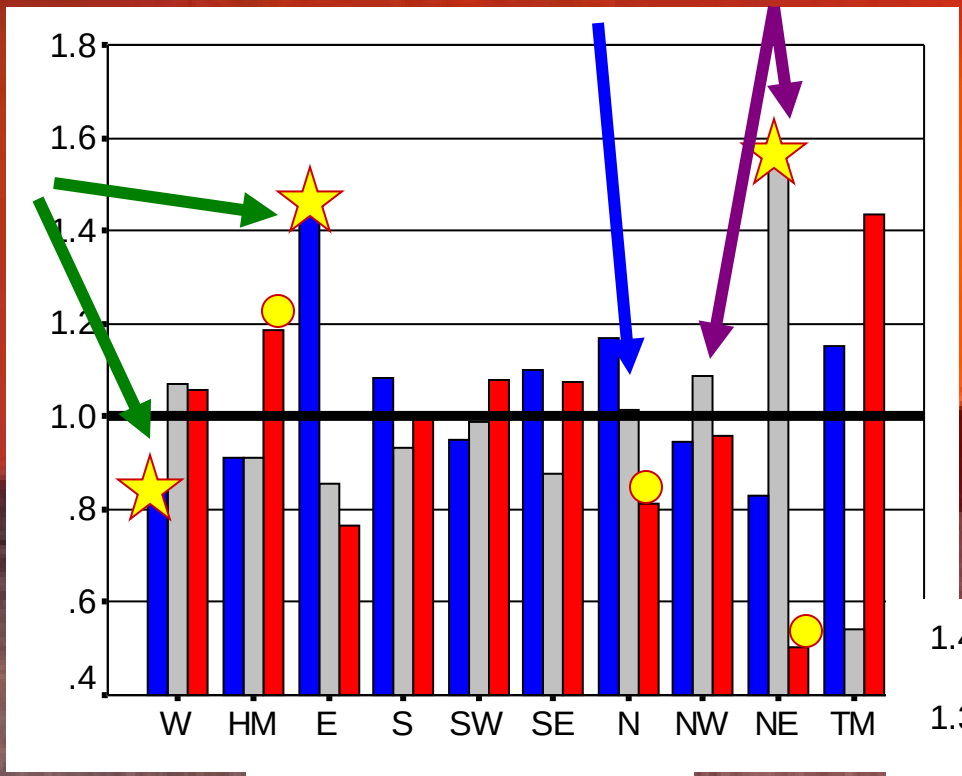
	low	medium	high
solar	13,1	16,1	16,5

central European low

TM



	low	medium	high
solar	1,4	1,1	2,5



major types

Relative frequency (1.0 = climatological mean)

N types – less frequent in solar maxima

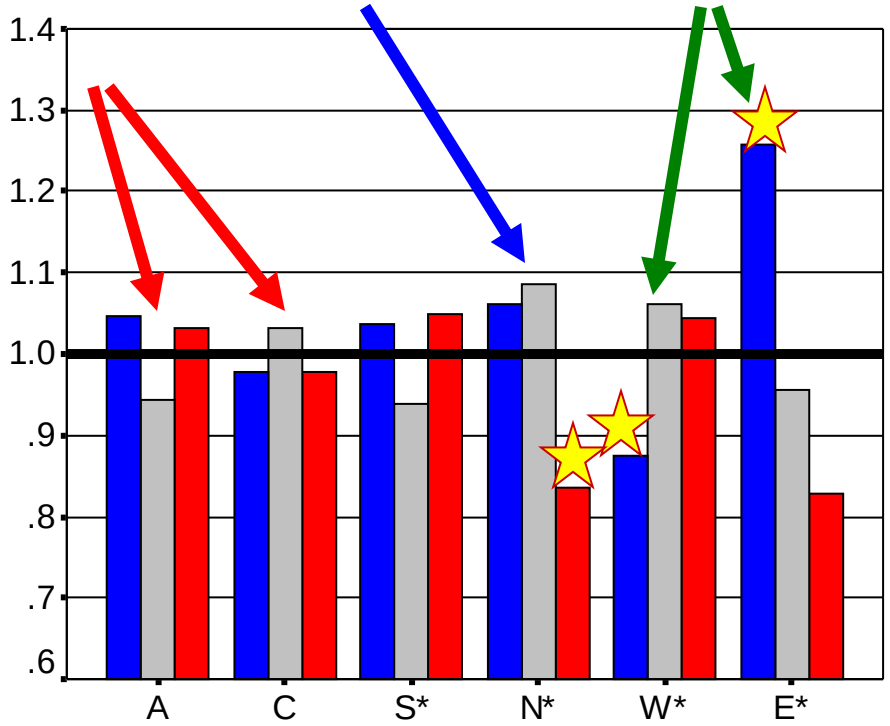
NW + NE types – most frequent in moderate solar activity

W / E types – less / more frequent in solar minima

moderate vs. high solar activity – little difference

A / C types – less / more frequent in moderate solar activity

supertypes



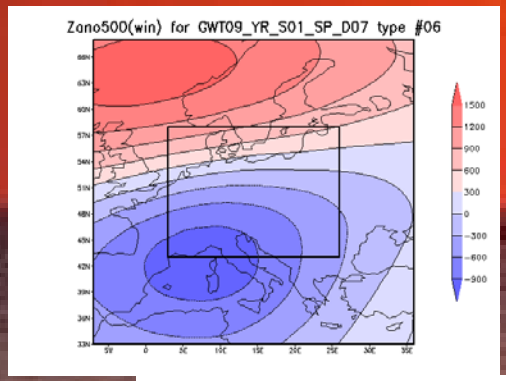
RESULTS, Hess&Brez

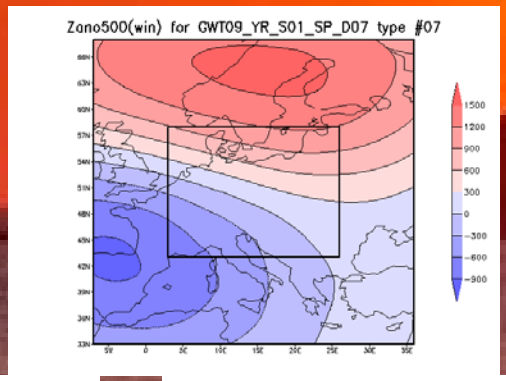
- Most striking effect – for quarters stratification:
  - low solar activity: W types **less than twice** as frequent as E types (39.5% vs. 20.4%)
  - moderate solar activity: W types almost **four times more** frequent than E types (49.5% vs. 12.8%)

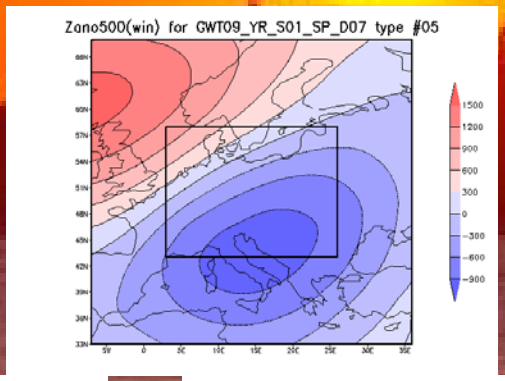
COST733 class's

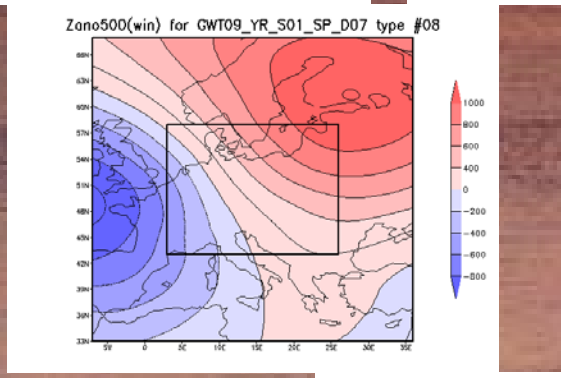
- ordered by the frequency ratio high / low solar
- i.e.
  - (top) left: types most frequent under low solar activity / least frequent under high solar activity
  - (bottom) right: types most frequent under high solar activity / least frequent under low solar activity

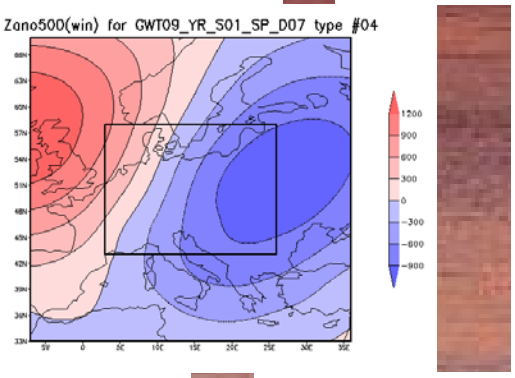
Example 1: GWT

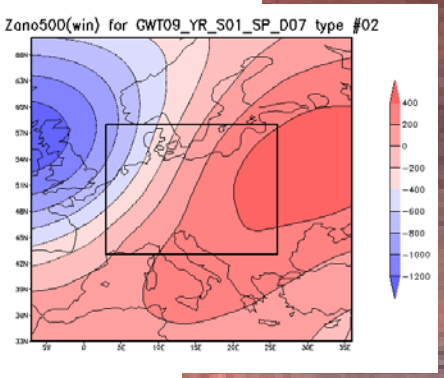


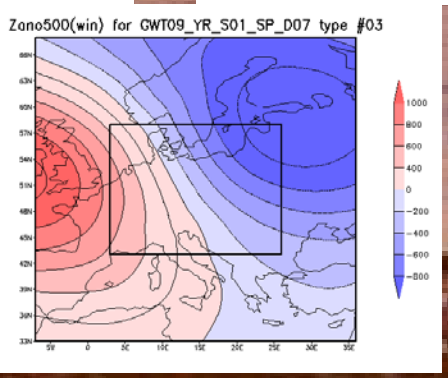


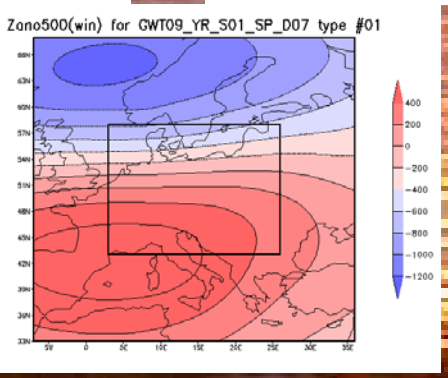




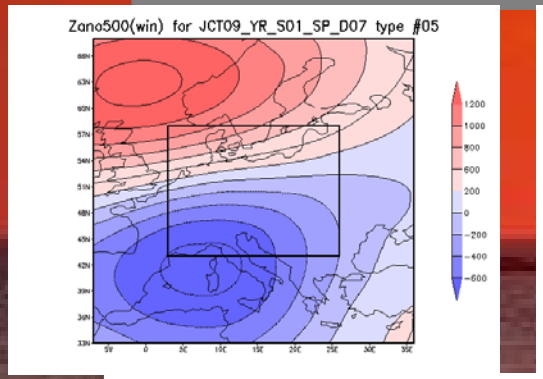


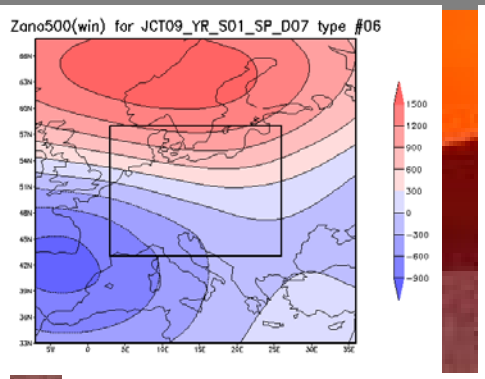


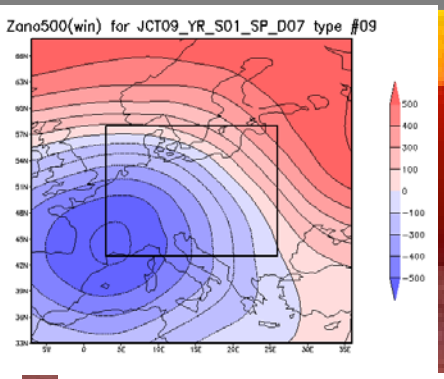


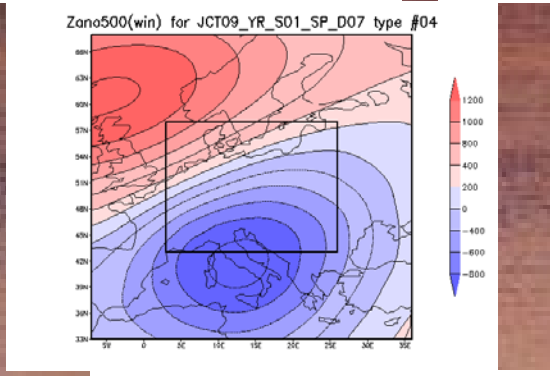


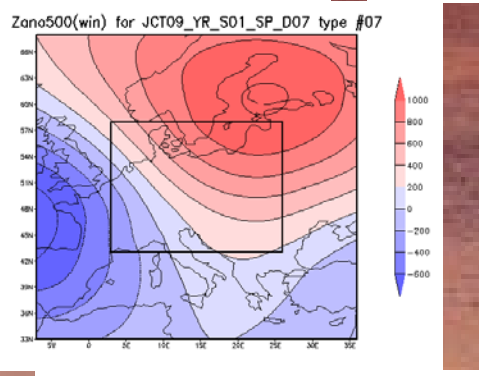
Example 2: JCT

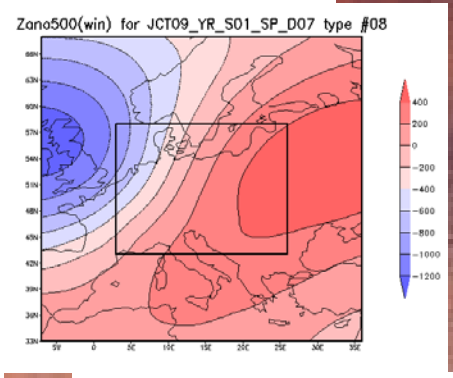


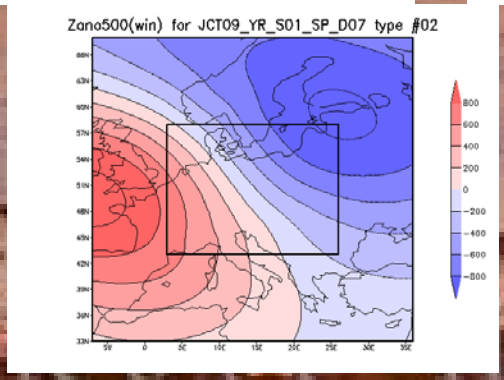


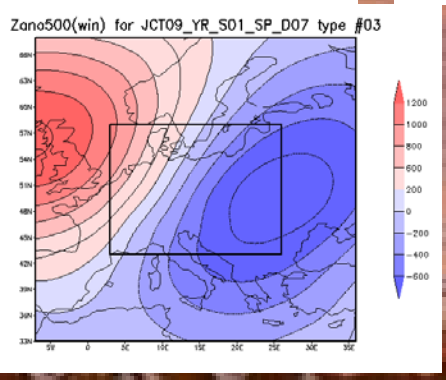


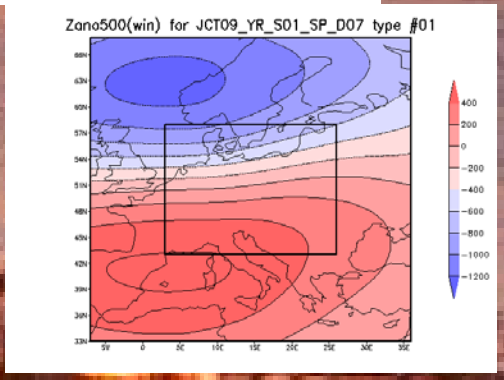




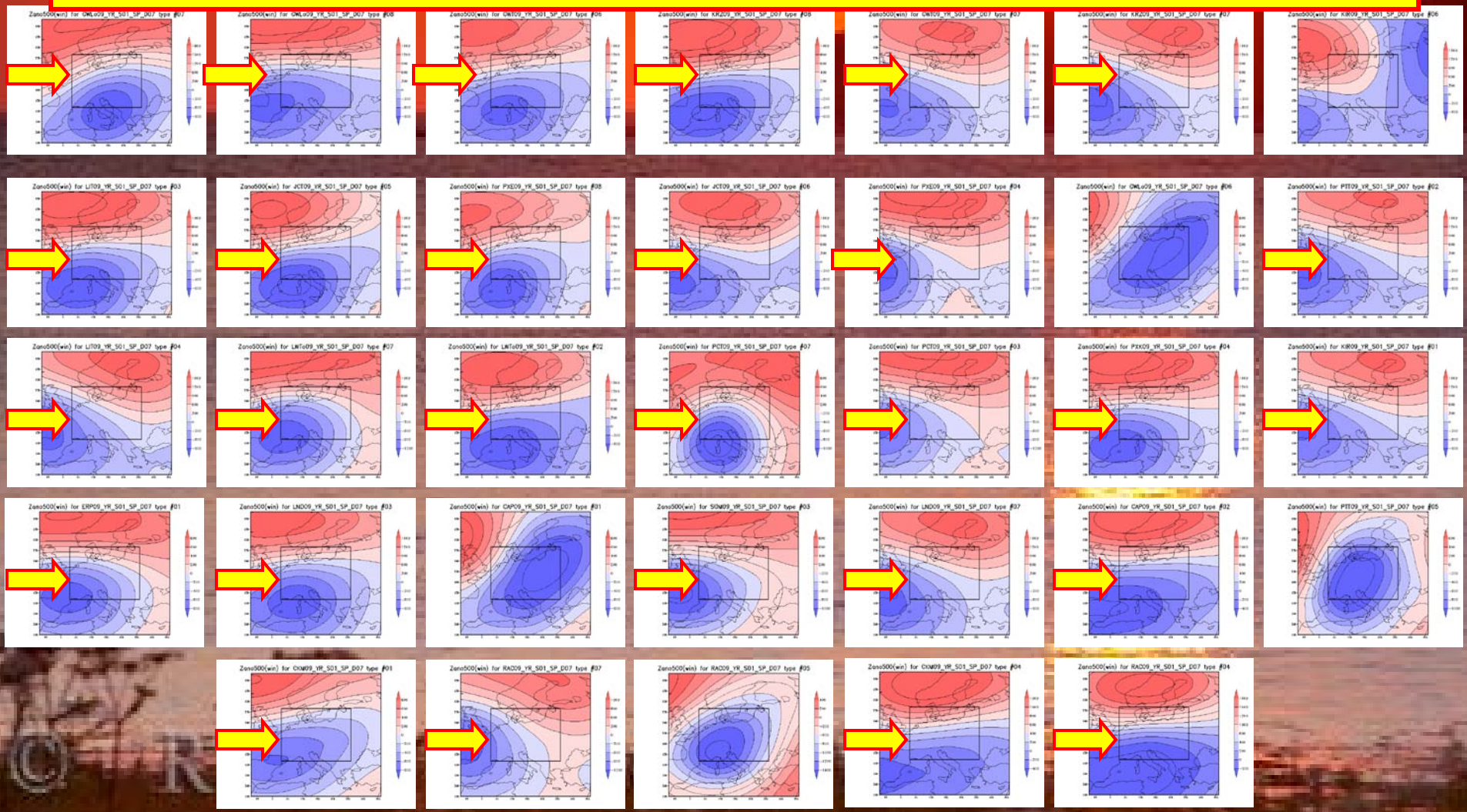






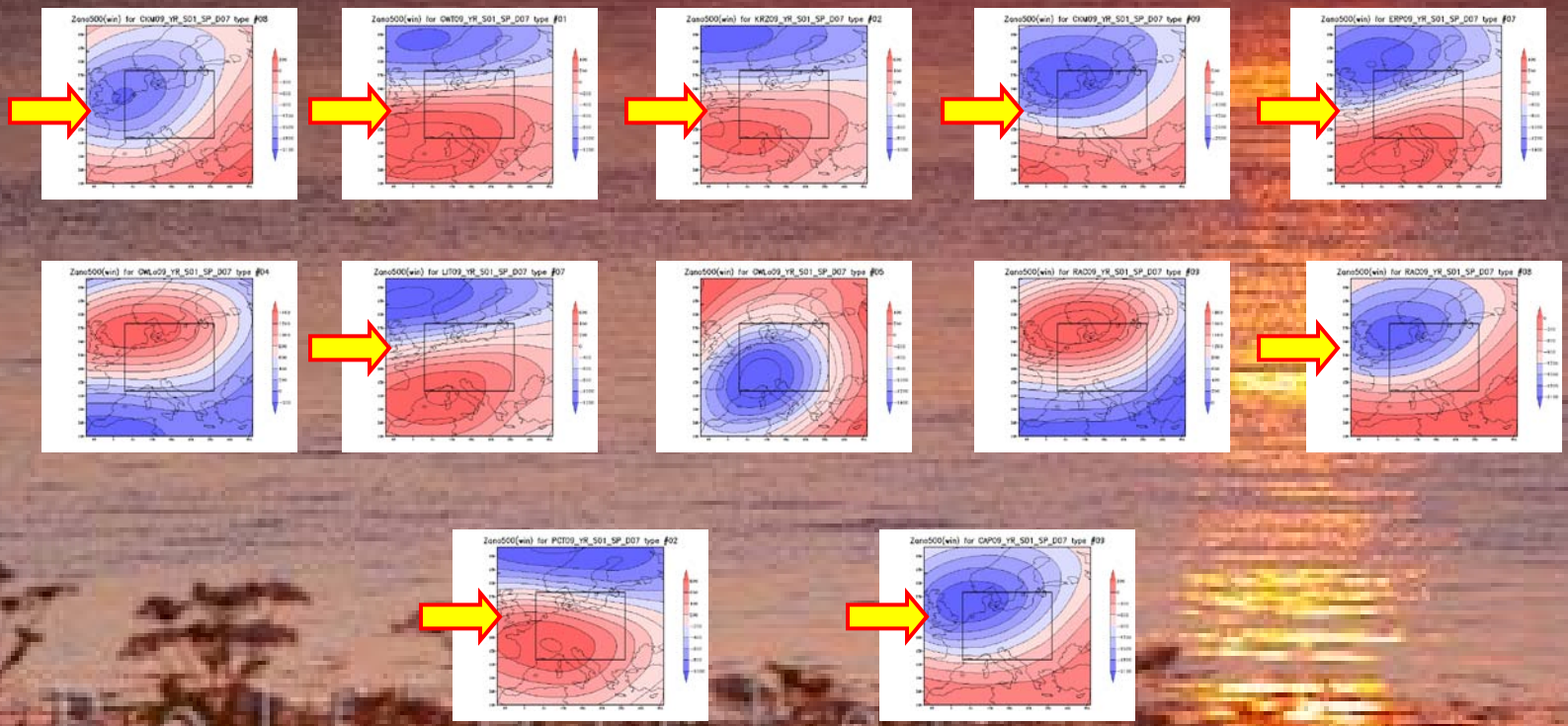


All classifications together: types signigicantly more frequent in minima / types with easterly flow prevail



All classifications together: types significantly more frequent in maxima / less frequent in minima

types with westerly flow prevail



CONCLUSIONS

- effects of solar activity on NH tropospheric circulation are significant, some are surprisingly strong
- in solar maxima:
  - ❑ zonalization of flow over North Atlantic and Europe