Progress on the Seasonal Dependence of the Sensitivity of ICON model parameters over the Central Mediterranean Region

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Collaboration and Support:

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2. Israel Meteorological Service (IMS)
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4. Deutscher Wetterdienst (DWD)

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WORK OVERVIEW

- The goal of this effort is to gauge the sensitivity of ICON model over a large number (**24**) of parameters towards the establishment of ICON-LEPS in place of the currently operational COSMO-LEPS.
- The consequent list of the parameters considered of interest for the corresponding perturbations in ICON-LEPS has been decided and ranked according to their estimated signicance by ICON experts, (*Schlemmer etal*, http://cosmo-model.org/content/support/icon/tuning/icon-tuning.pdf).
- Almost all of the parameters are tested over a domain covering the wider area of Greece and Italy for a period of 123 dates i.e., January, April, July and October 2020 using the ICON model installed by the Israeli Meteorological service (IMS) at ECMWF and using computational resources provided gratis by the Hellenic National Meteorological Service (HNMS).
- The model sensitivities are presented for 16 surface fields over the area average of the whole period as well as for January, April, July and October separately for the last lead time (132nd hour) of the model runs where sensitivity is expected to be on its climax.

SENSITIVITY TESTS BLUEPRINT

24 parameters are considerd.

⊗

3 values/parameter including default.

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The evaluation period consisted of 123 days from year 2020 i.e., January 1-31, April 1-30, July 1-31, October 1-31.

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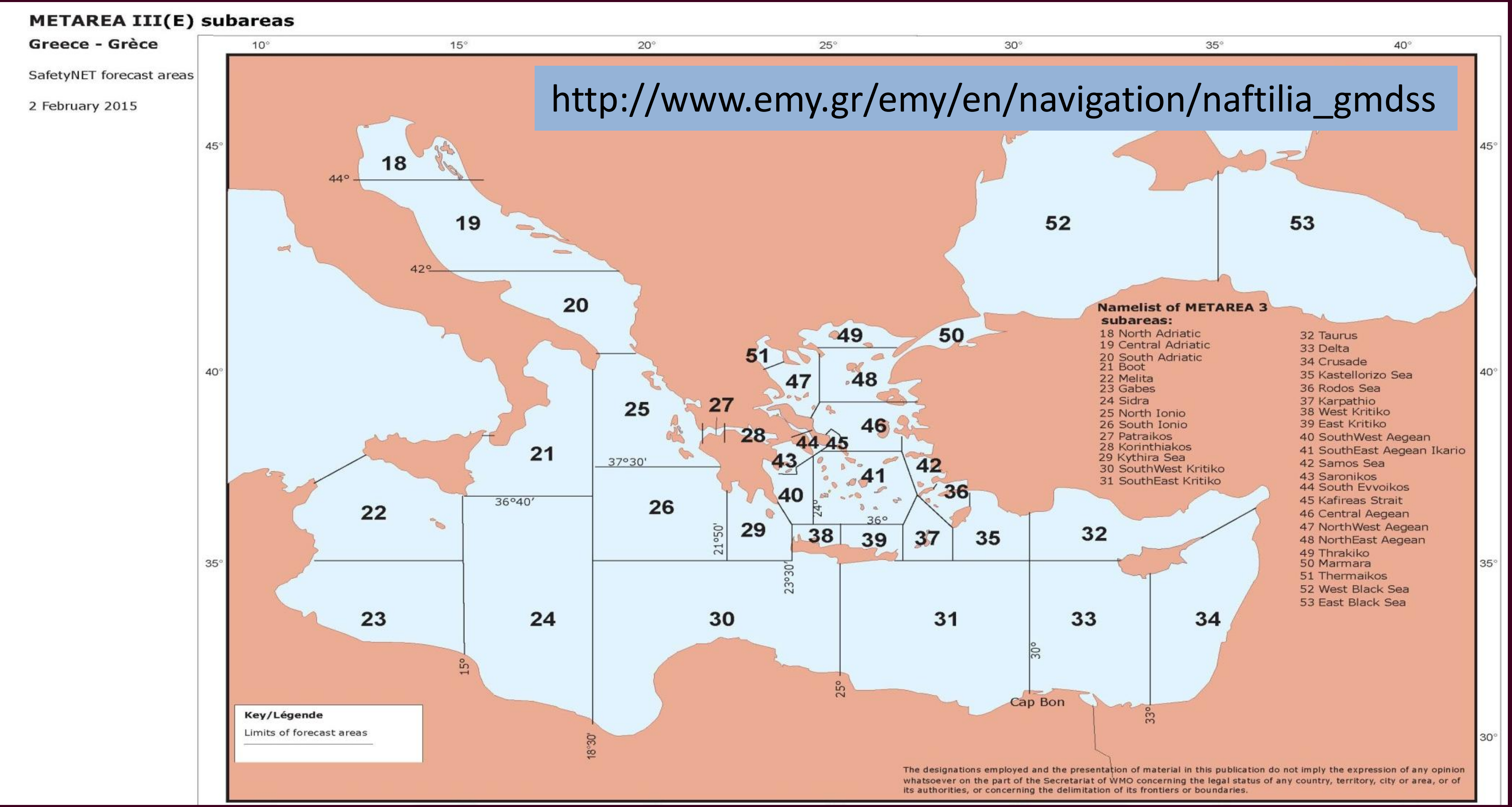
6000 runs based on ICON-IMS:

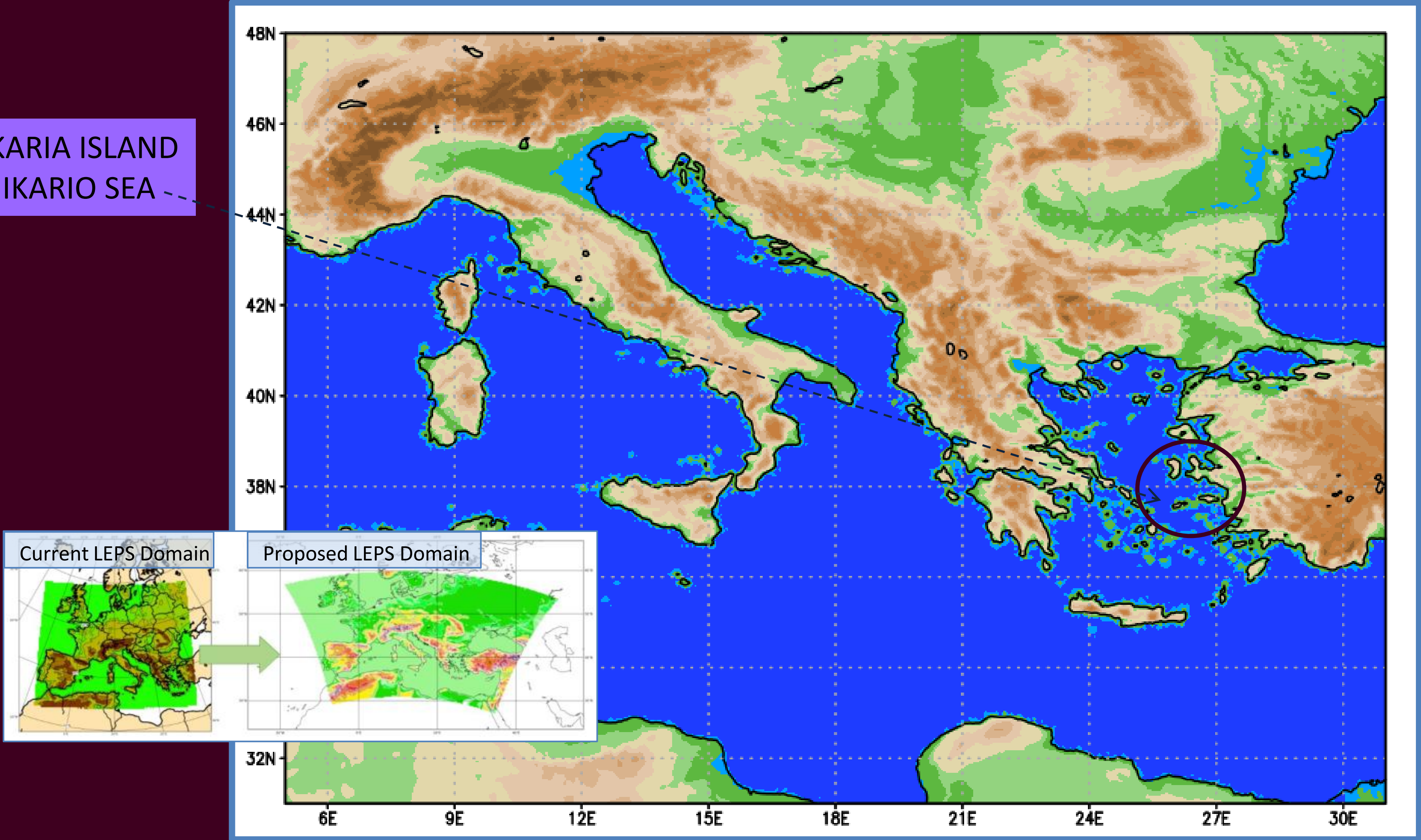
- Horizontal grid size: R3B08 (~6.5km).
- 417x273 grid points (wider area of Greece and Italy), 65 levels.
- Integration time-step: 60 secs.
- Integration period: 132 hs.
- Boundary conditions : 3hr IFS Forecast.
- Computational Cost ~ 10^7 b.u. on Cray X C40 of ECMWF (Gratis HNMS).

MOTIVATION: On the 1st of February 1999 the IMO's Global Maritime Distress and Safety System (GMDSS) was implemented, in which METAREAs were established and Greece assumed the role of "Issuing Service" for METAREA III. That is Greece is responsible for the meteorological support of shipping in the Mediterranean and the Black Sea by the sending of WARNINGS and FORECASTS by satellite means. HNMS issues the above bulletins for the Eastern Mediterranean and the Black Sea, while Meteo France issues for the Western Mediterranean respectively, however is the Issuing Service that is responsible for the transmission to the ships of both bulletins. Within the IMO/WMO WWMIWS framework, Greece has assumed the role of "METAREA Coordinator", who is responsible for the smooth operation of the GMDSS system in METAREA III.



Domain under consideration

IKARIA ISLAND
IKARIO SEA



CONSIDERED PARAMETERS (min,default,max)

- Subscale Orography tunning: Low level wake drag constant for blocking- **gkwake** (1.0 , 1.5, 2.0)

- Grid Scale Microphysics:
  - Terminal fall velocity of ice - **zvz0i** (0.85 , 1,25, 1.45),
  - Raindrop size distribution change - **rain_n0_factor** (0.02 , 0.1, 0.5)

- Cloud Cover:
  - Box width for liquid cloud diagnostic - **box_liq** (0.03, 0.05, 0.07),
  - Liquid cloud diagnostic asymmetry factor - **box_liq_asy** (2.0 , 3.5, 4.0)

- Terra:
  - Evaporating fraction of soil - **c_soil** (0.75, 1.0, 1.25)
  - Scaling for maximum interception storage - **cwimax_ml** (0.5×10^{-7} , 1.0×10^{-6}, 0.5×10^{-4})

contd

CONSIDERED PARAMETERS (min,default,max)

- Turbulence:
  - Asymptotic maximal turbulent distance (m) - **tur_len** (250, 300, 350),
  - Normalised supersaturation critical value - **q_crit** (1.6, 2.0, 4.0),
  - Scale for the separated horizontal shear mode **- a_hshr** (0.1, 0.0, 2.0)
  - Stability correction of turbulent length scale factor - **a_stab** (0.0, 0.0, 1.0)
  - Length scale factor for vertical diffusion of TKE - **c_diff** (0.1, 0.2, 0.4)
  - Lower bound of velocity-dependent *Charnock* parameter **- alpha0** (0.0123, 0.0123, 0.0335)
  - Scaling the molecular roughness of water waves - **alpha1** (0.1, 0.5, 0.9)
  - Common scaling for minimum vertical diffusion for heat-moisture and momentum **- tkhmin=tkmmin** (0.55 , 0.75, 0.95)
  - Scaling of laminar boundary layer for heat and Latent and heat fluxes over water (constant product))- **rlam_heat** (and simultaneous change of **rat_sea**) ((0.25,28.0), (1.0,7.0), (4.0,1.75))

contd

CONSIDERED PARAMETERS (min,default,max)

- <u>Convection</u>:
  - Entrainment convection scheme **valid for dx=20km - entrorg** (0.00175, 0.00195, 0.00215)
  - Maximum allowed shallow convection depth **- rdephts** (15000, 20000, 25000)
  - Excess value for temperature used in test parcel ascent **- texc** (0.075, 0.125, 0.175)
  - Test parcel ascent excess grid-scale QV fraction **- qexc** (0.0075, 0.0125, 0.0175)
  - Precipitation coefficient conversion of cloud water **- rprcon** (0.00125, 0.0014, 0.00165)
  - Extratropics CAPE diurnal cycle correction **- capdcfac_et** (0.0, 0.5, 1.25)
  - RH threshold for onset of evaporation below cloud base over land **- rhebc_land** (0.80, 0.85, 0.90)
  - RH threshold for onset of evaporation below cloud base over ocean **- rhebc_ocean** (0.70, 0.75, 0.80)

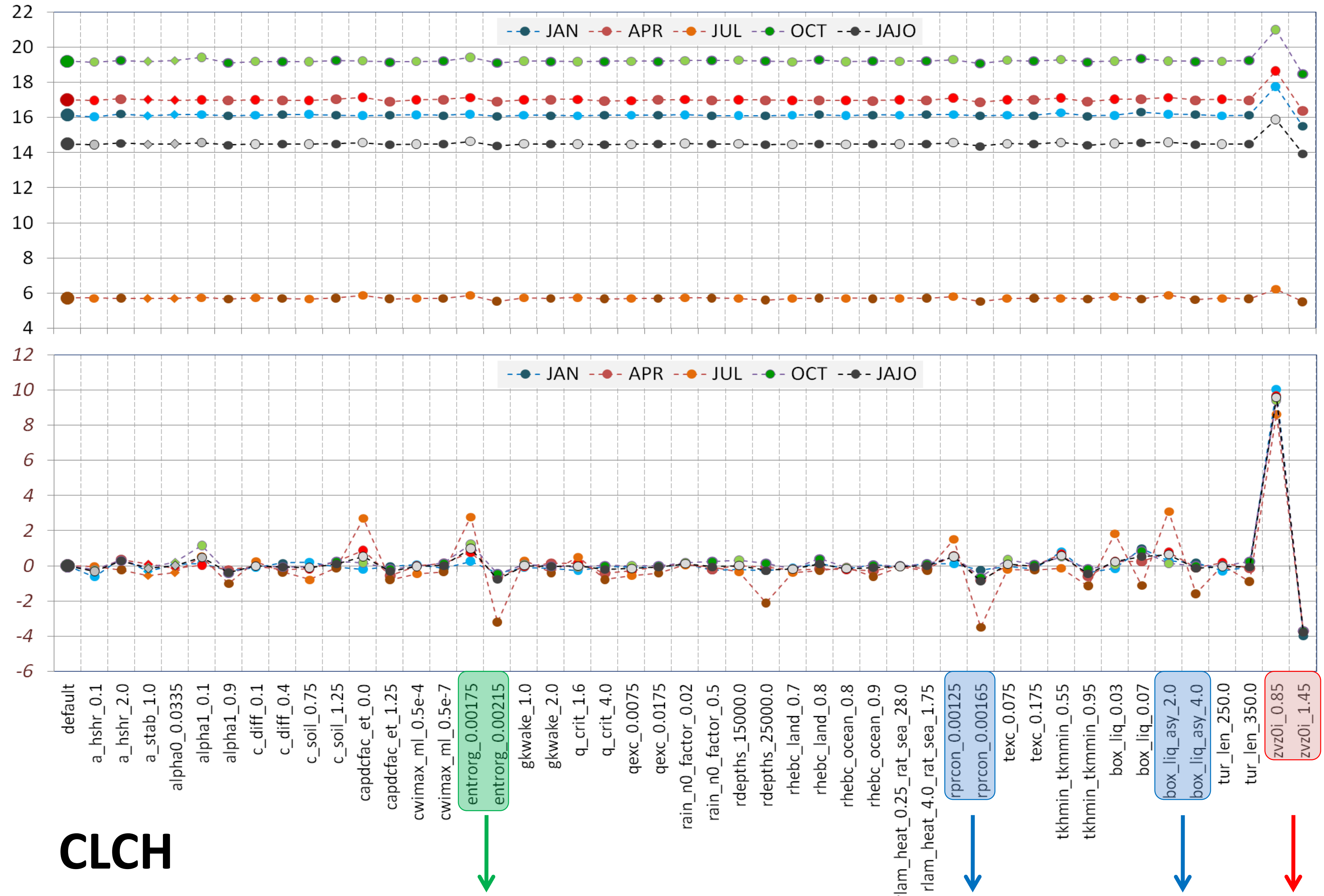
INVESTIGATED VARIABLES

<T2m>	2m Temperature [K]
<Tmax2m>	Max 2m Temperature [K]
<Tmin2m>	Min 2m Temperature [K]
<Td2m>	Dew point 2 m Temperature [K]
<tot_prec>	AccumulatedPrecipitation [kg/m^2]
<pmsl>	Mean sea level Presure [Pa]
<u10m>	10 m wind speed u component [m/s]
<v10m>	10 m wind speed v component [m/s]
<gust10m>	Wind gust 10 m above ground [m/s]
<clcl>	Low cloud cover [1-100]
<clcm>	Medium cloud cover [1-100]
<clch>	High cloud cover [1-100]
<clct>	Total cloud cover [1-100]
<tqv>	Column integrated water vapour [kg/m^2]
<tqi>	Total column integrated cloud ice [kg/m^2]
<tqc>	Total column integrated cloud water [kg/m^2]

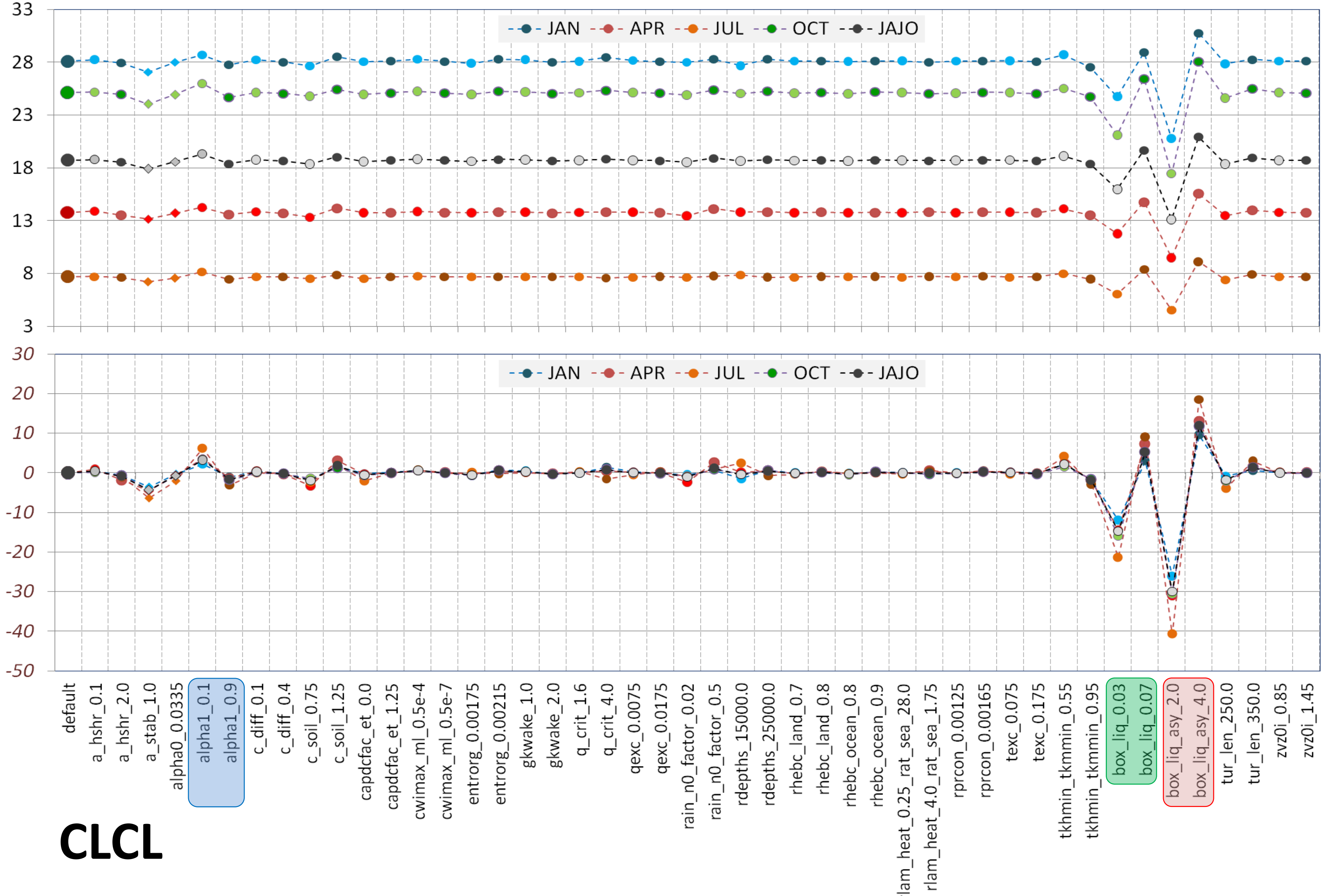
<V>: Area Average at the 132h forecast hour.

Sensitivity of $<V>$

$$S_{P<V>}(\%) = 100 \bullet \left(\frac{<V>_P}{<V>_D} - 1\right)$$



THE MOST SENSITIVE PARAMETERS FOR THE CONSIDERED FIELDS ARE GAUGED FROM RED TO BLUE (MAINLY HEURISTICALLY)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a_hshr_2.0
a_stab_1.0
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alpha1_0.1
alpha1_0.9
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q_crit_1.6
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rain_n0_factor_0.5
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rdepths_25000.0
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rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
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rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
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box_liq_0.07
box_liq_asy_2.0
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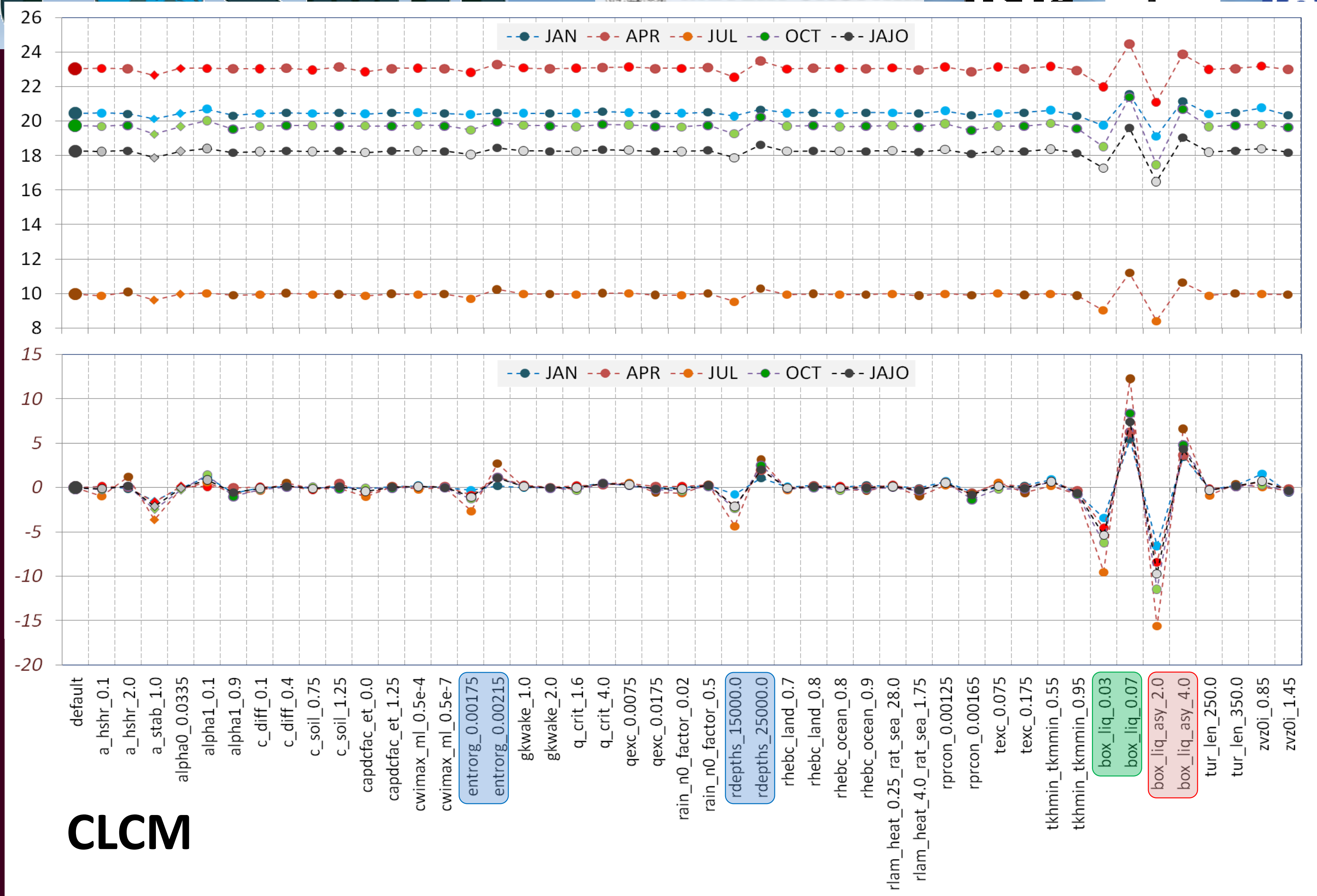
zvz0i_1.45

CLCL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texc_0.075
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tkhmin_tkmmin_0.55
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box_liq_0.03
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box_liq_asy_2.0
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zvz0i_1.45
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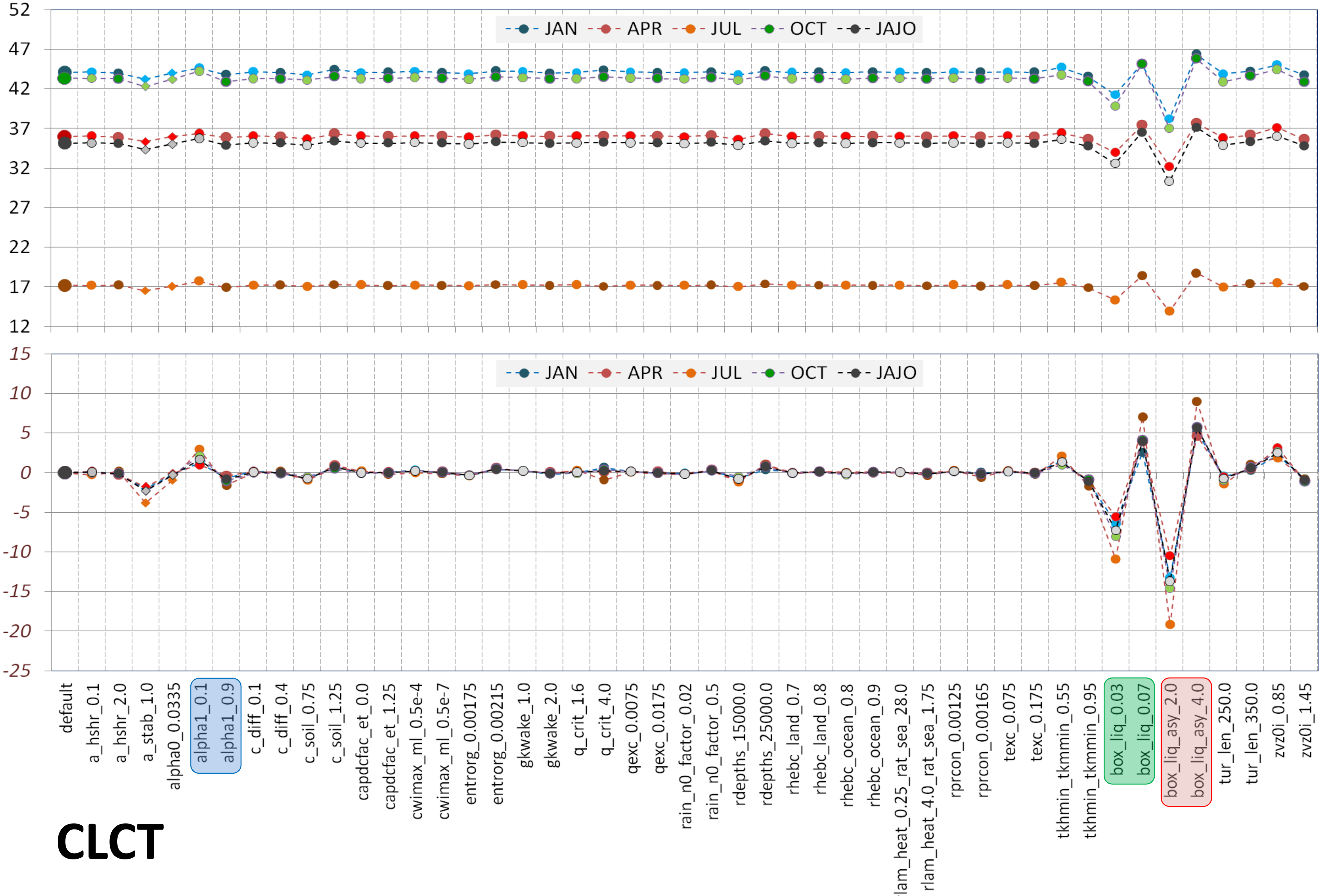
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rhebc_ocean_0.8
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texc_0.075
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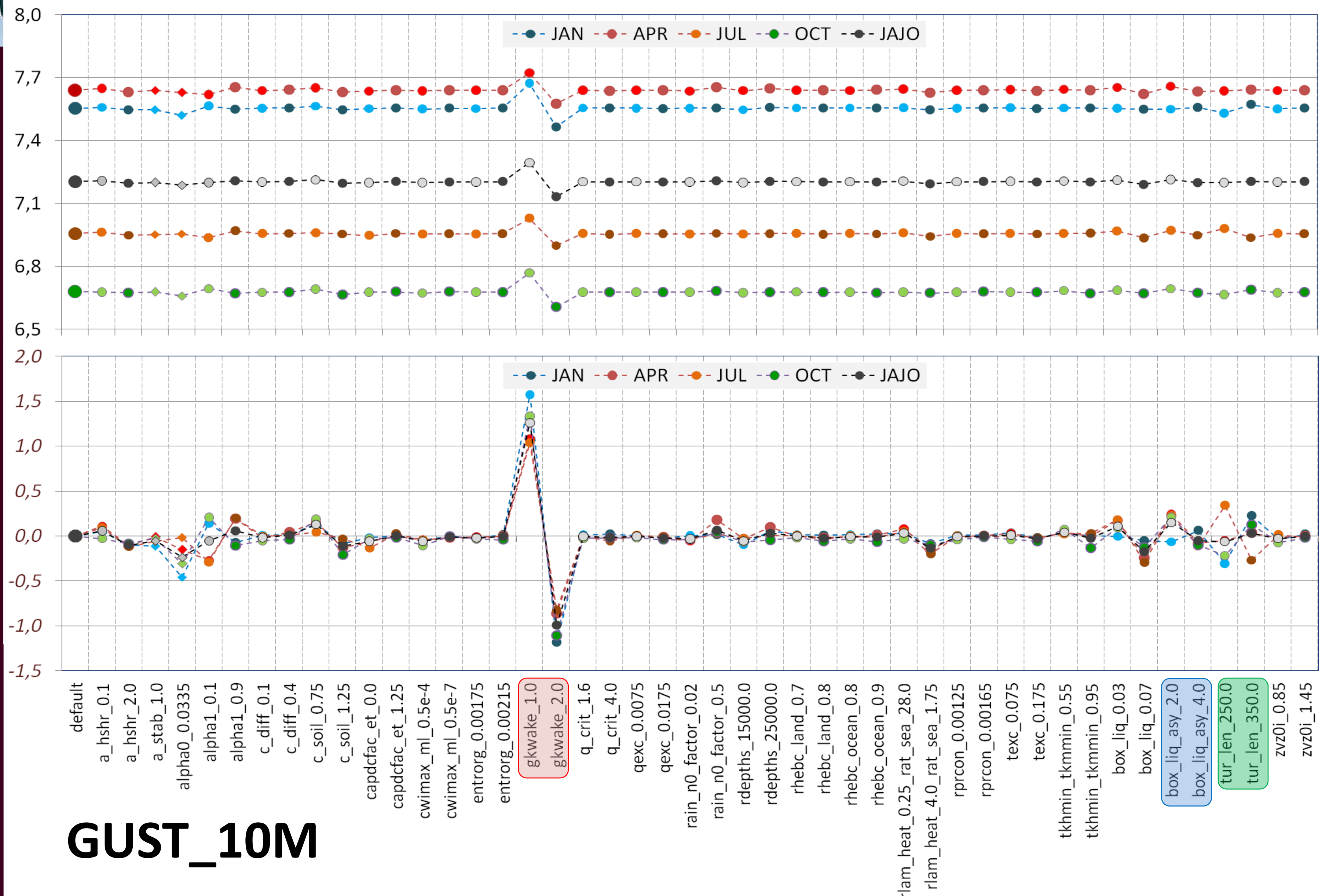

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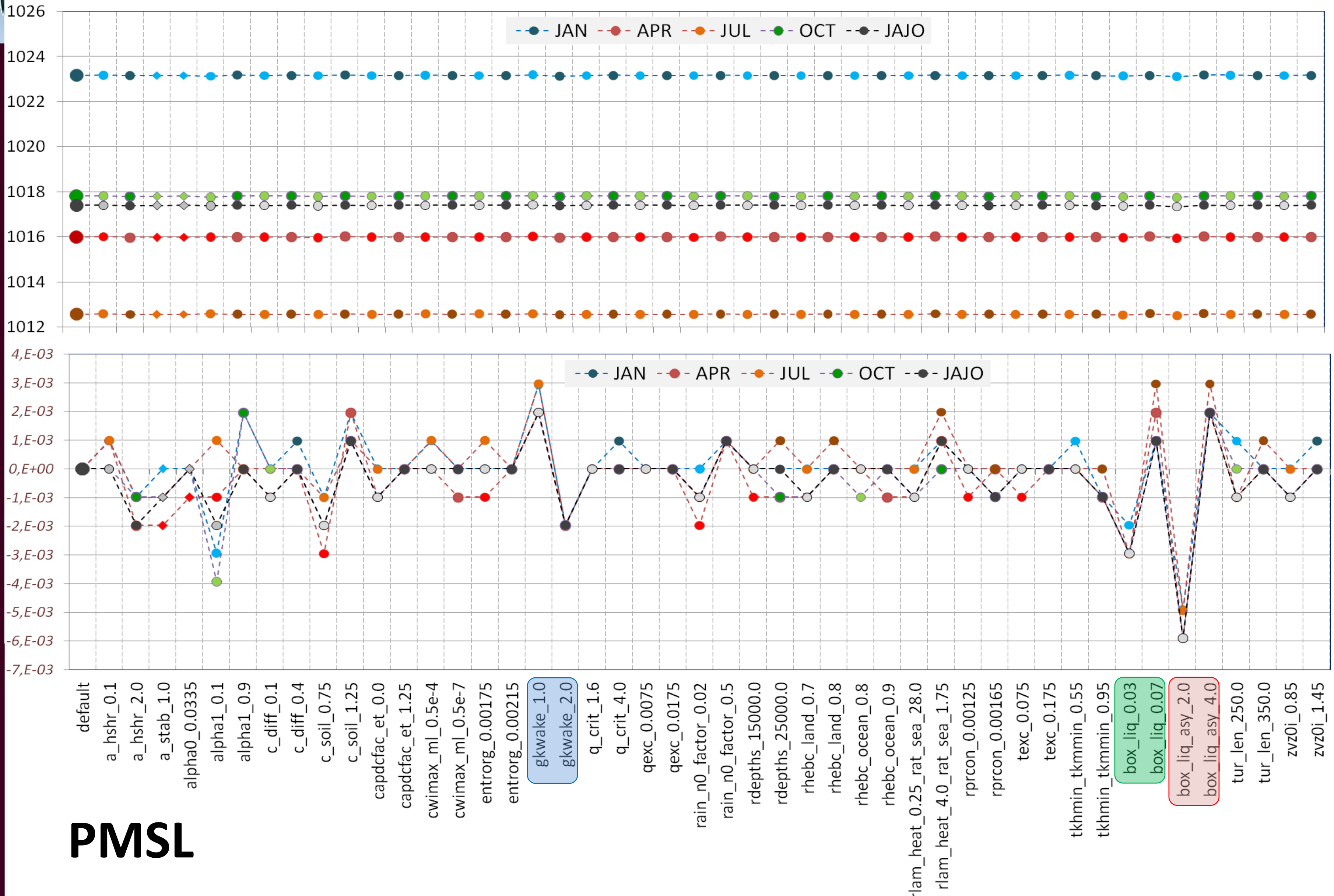
GUST_10M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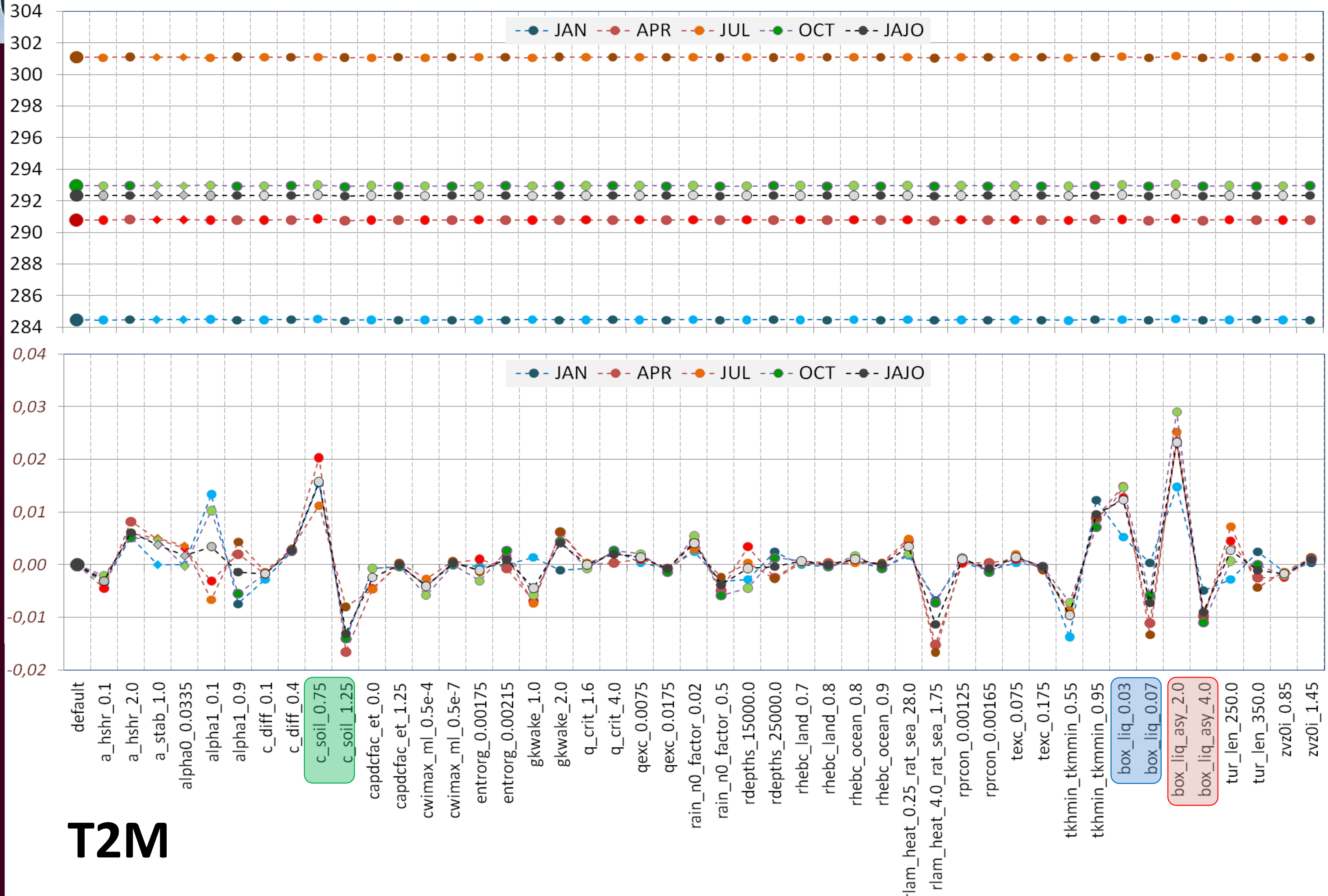
PMSL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alpha1_0.1
alpha1_0.9
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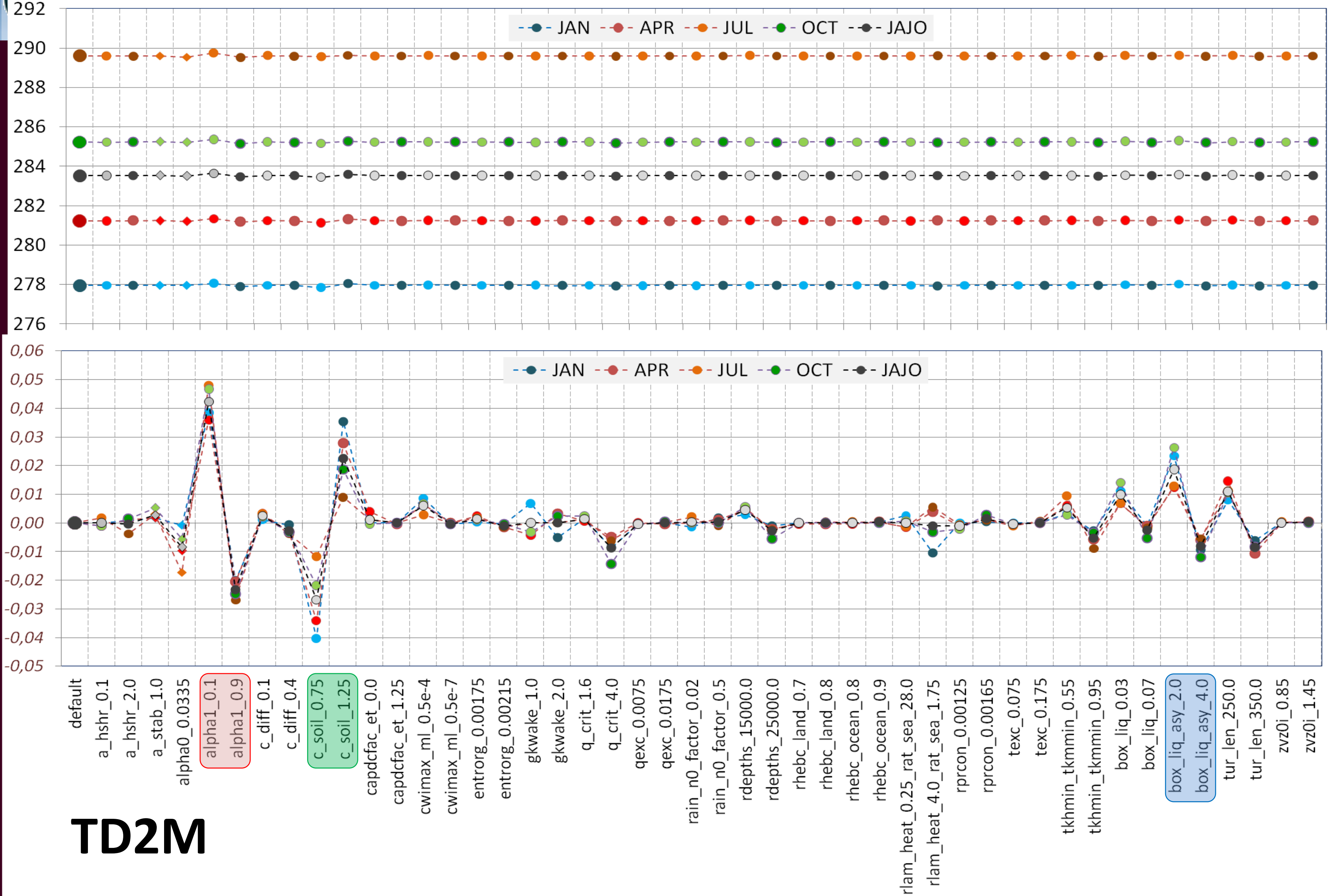
T2M



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q_crit_4.0
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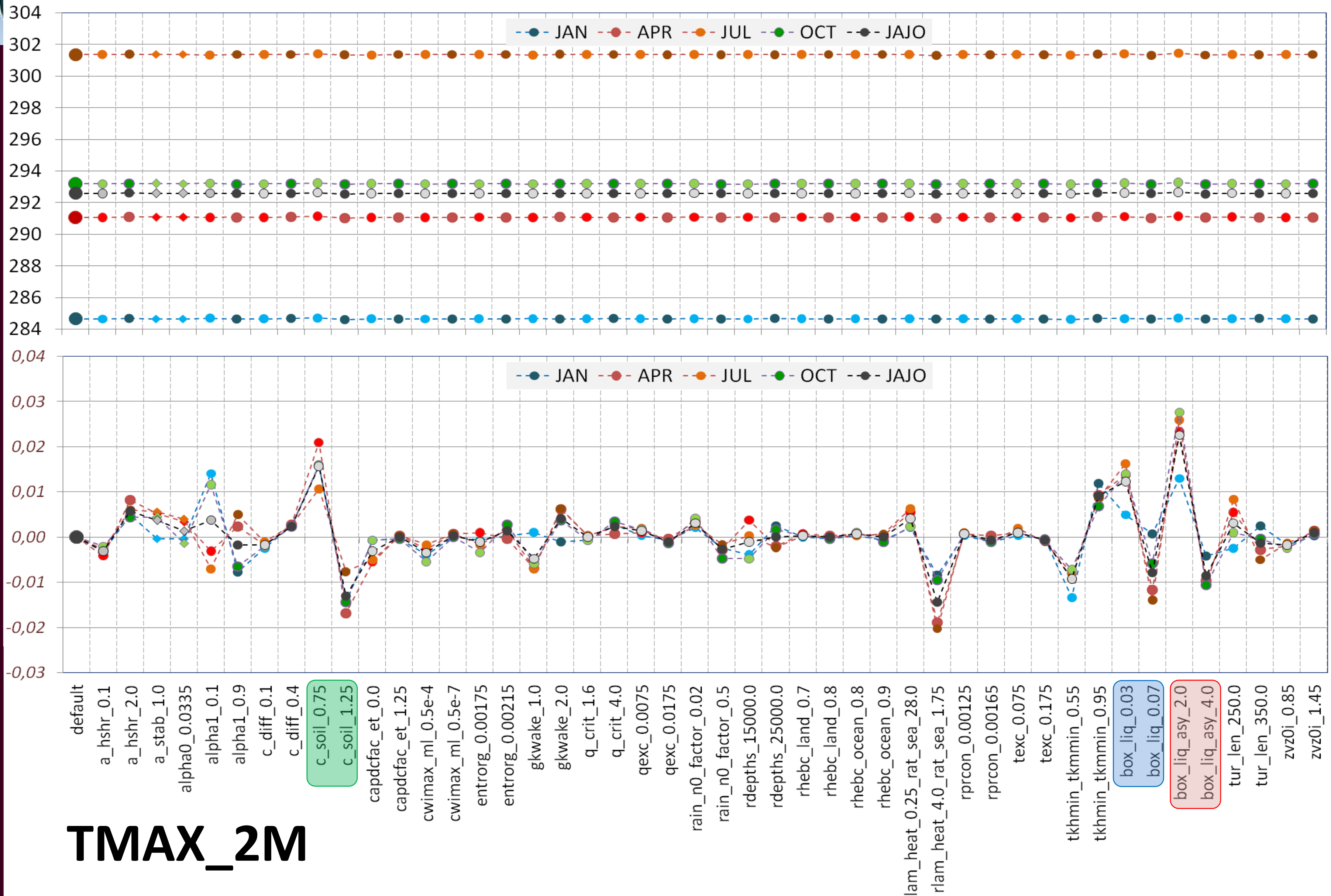
TD2M

TMAX_2M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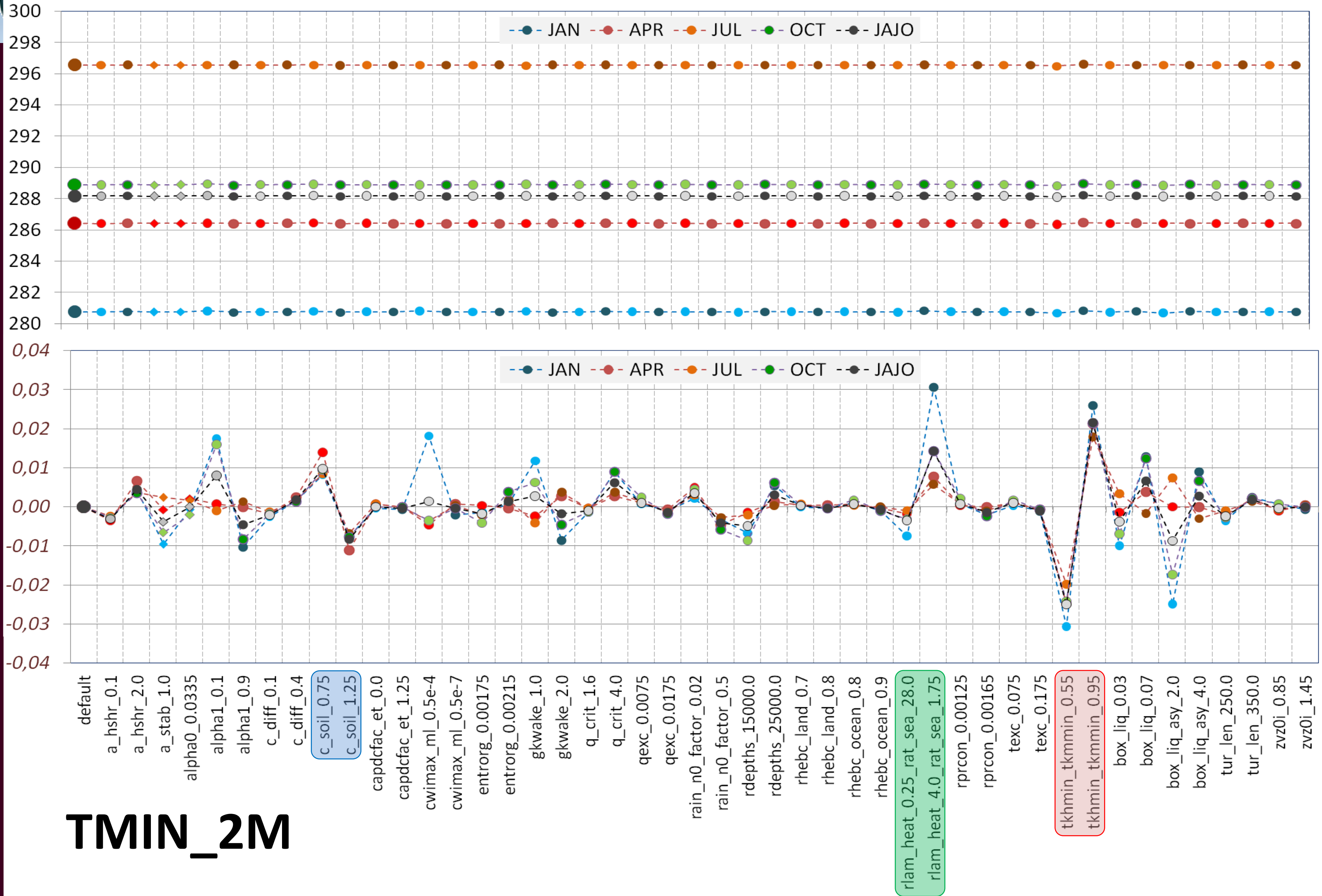

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capdcfac_et_1.25
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cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
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tur_len_350.0
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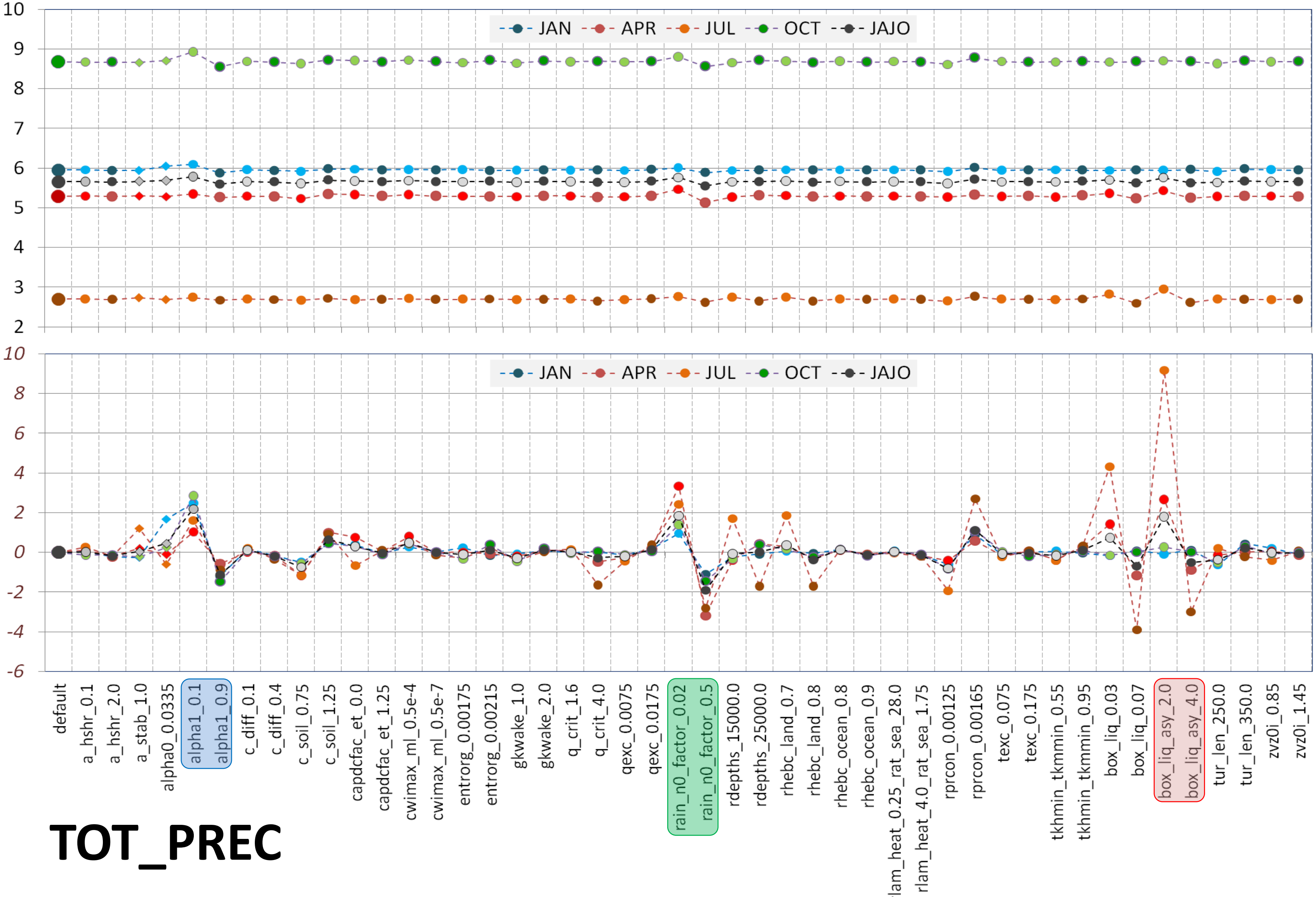
zvz0i_1.45

TMIN_2M



JAN APR JUL OCT JAJO
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a_hshr_2.0
a_stab_1.0
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alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
capdcfac_et_1.25
cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
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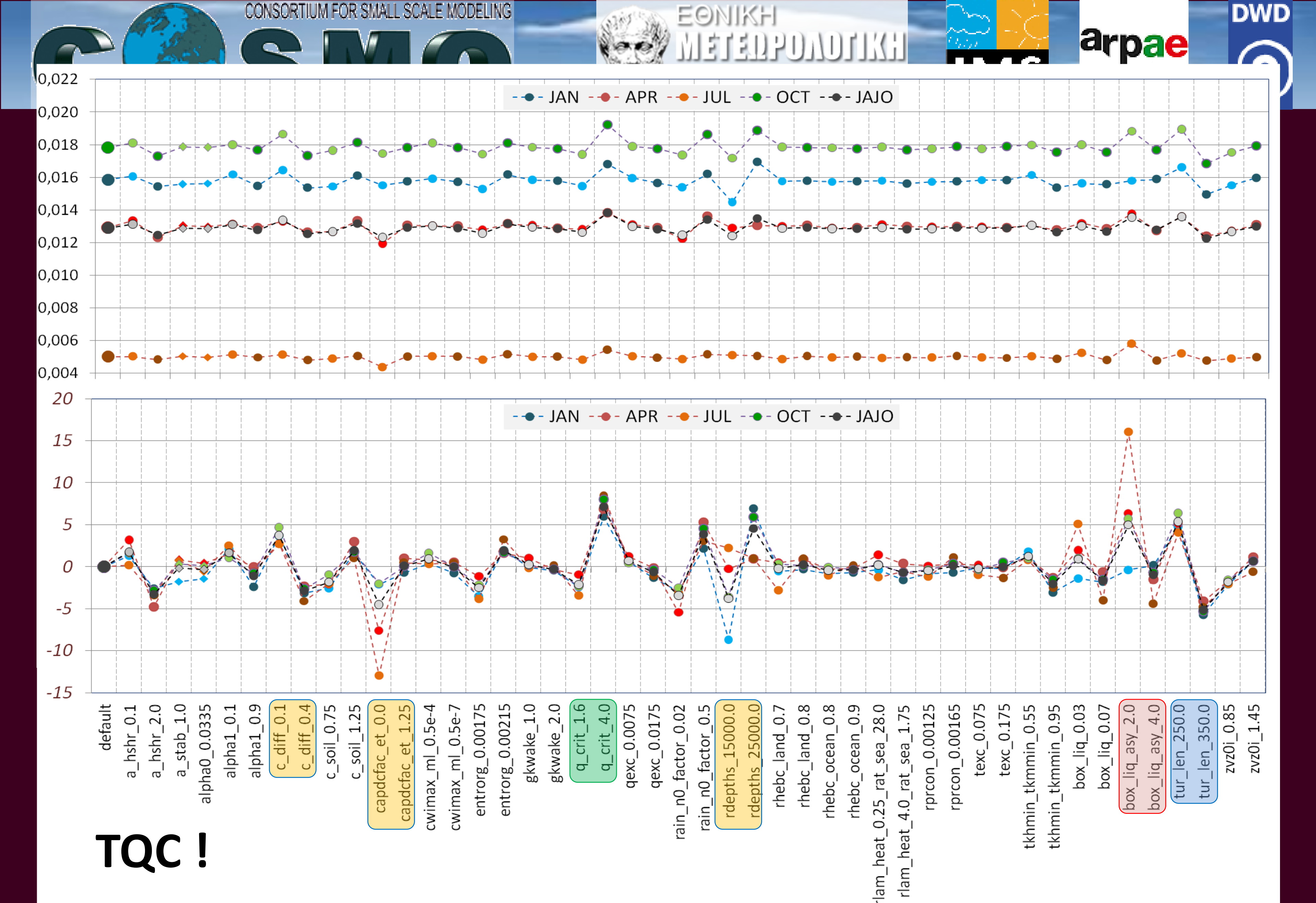
zvz0i_1.45

TOT_PREC


CONSORTIUM FOR SMALL SCALE MODELING
ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ
arpae
DWD
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0,020
0,018
0,016
0,014
0,012
0,010
0,008
0,006
0,004
JAN APR JUL OCT JAJO
20
15
10
5
0
-5
-10
-15
default
a_hshr_0.1
a_hshr_2.0
a_stab_1.0
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alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
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cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
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q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
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box_liq_0.07
box_liq_asy_2.0
box_liq_asy_4.0
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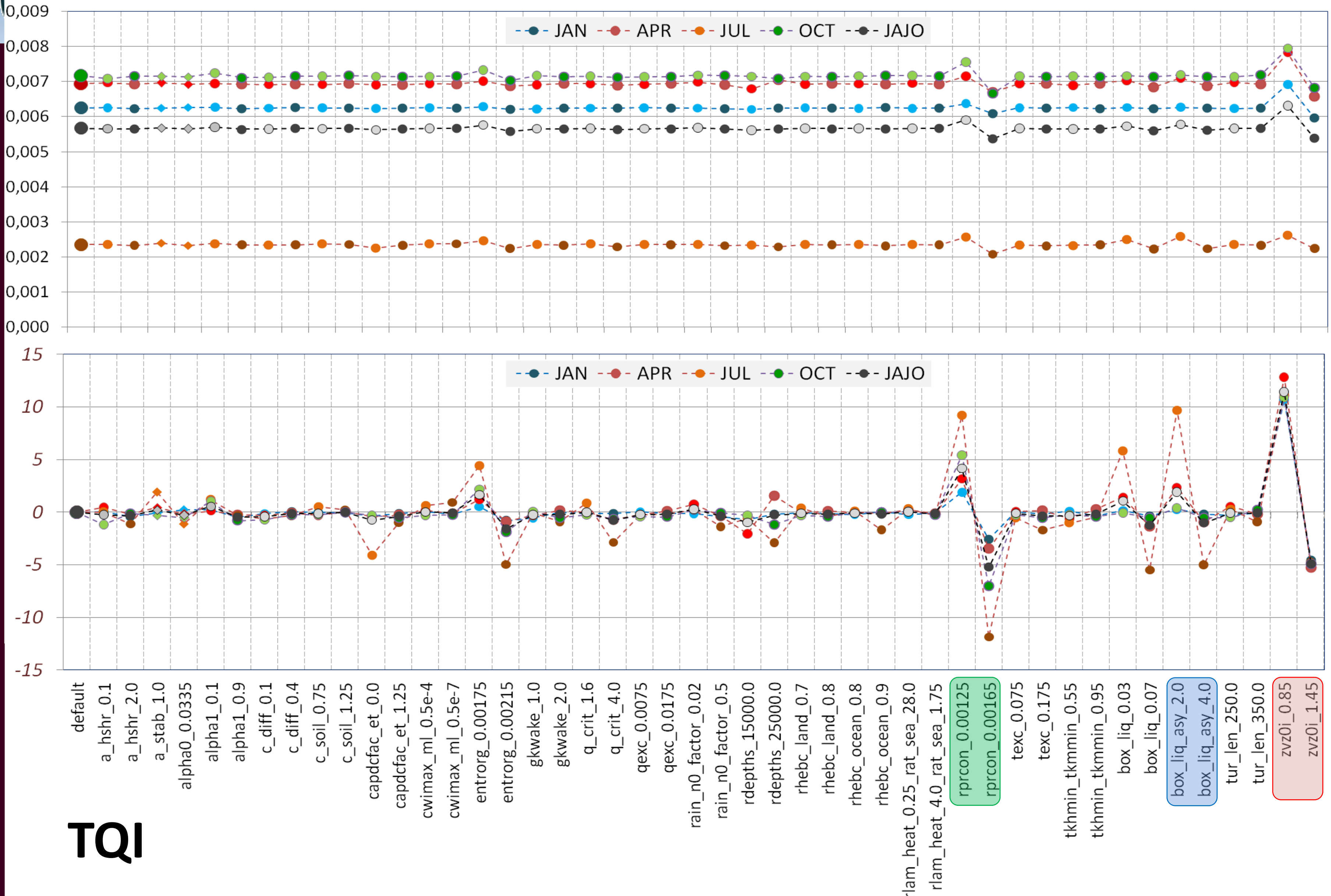
tur_len_350.0
zvz0i_0.85
zvz0i_1.45

TQC !



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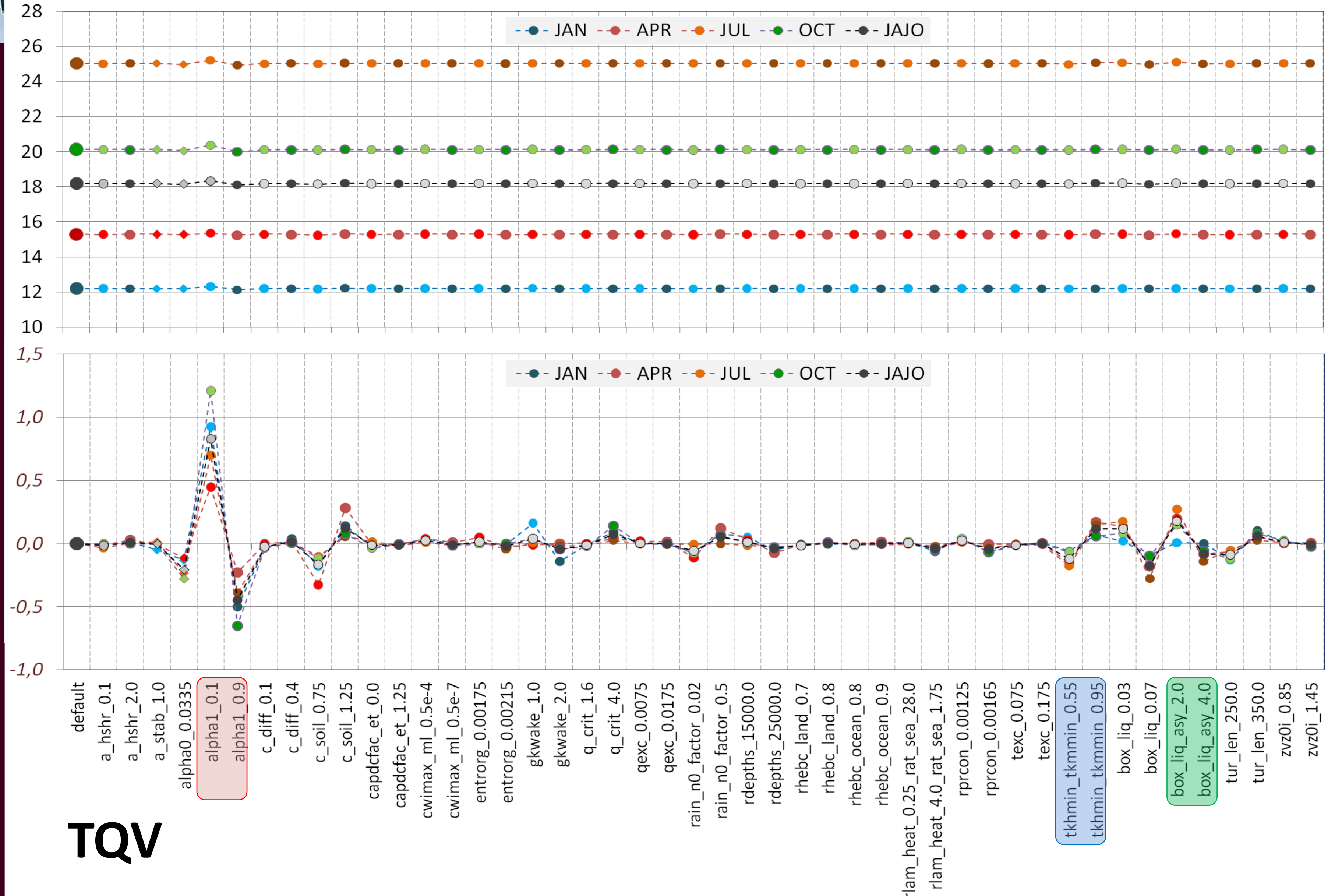
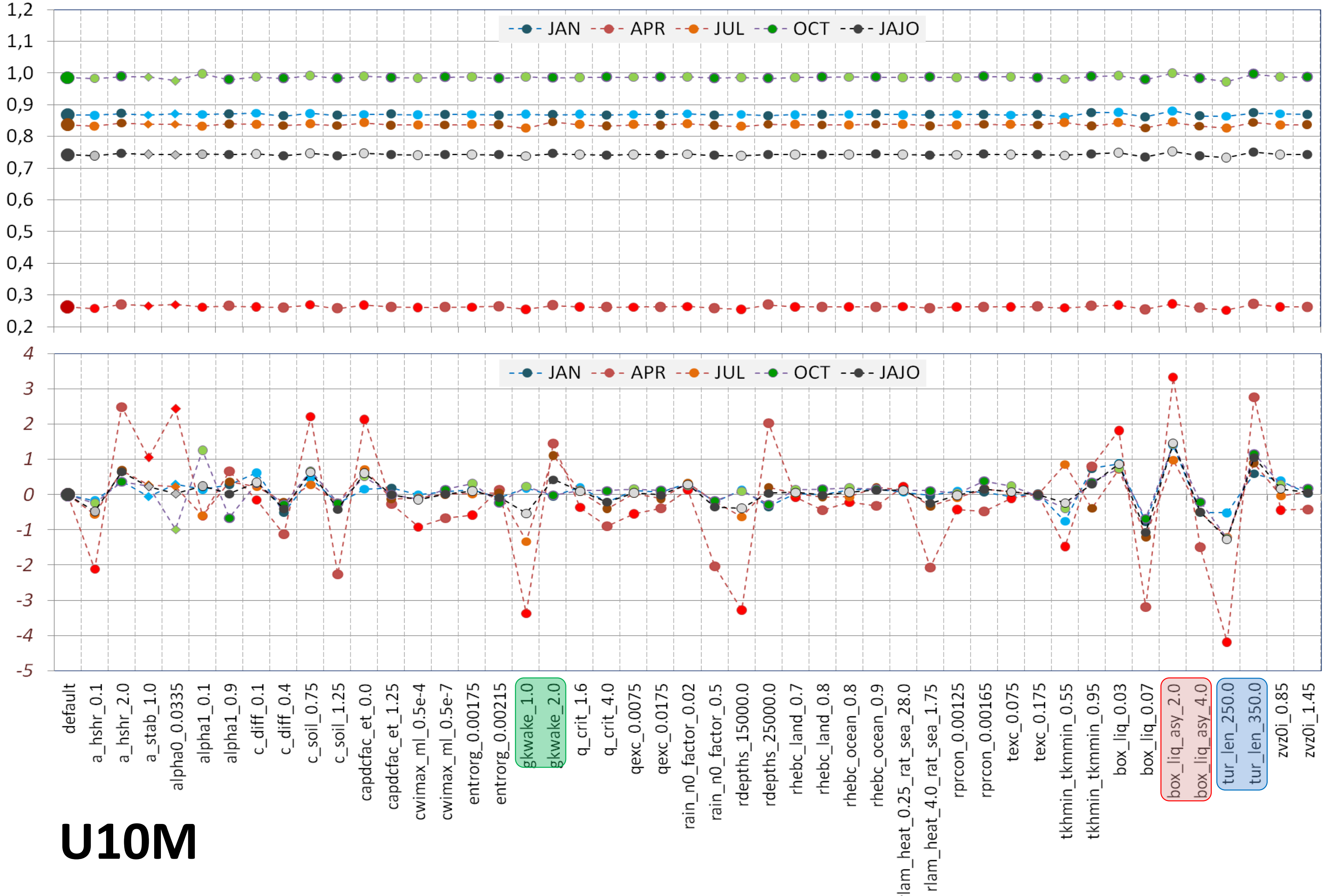
0,008
0,007
0,006
0,005
0,004
0,003
0,002
0,001
0,000
JAN APR JUL OCT JAJO
15
10
5
0
-5
-10
-15
JAN APR JUL OCT JAJO
default
a_hshr_0.1
a_hshr_2.0
a_stab_1.0
alpha0_0.0335
alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
capdcfac_et_1.25
cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
box_liq_asy_4.0
tur_len_250.0
tur_len_350.0
zvz0i_0.85
zvz0i_1.45

TQI



JAN
APR
JUL
OCT
JAJO
28
26
24
22
20
18
16
14
12
10
1,5
1,0
0,5
0,0
-0,5
-1,0
default
a_hshr_0.1
a_hshr_2.0
a_stab_1.0
alpha0_0.0335
alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
capdcfac_et_1.25
cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
box_liq_asy_4.0
tur_len_250.0
tur_len_350.0
zvz0i_0.85
zvz0i_1.45

TQV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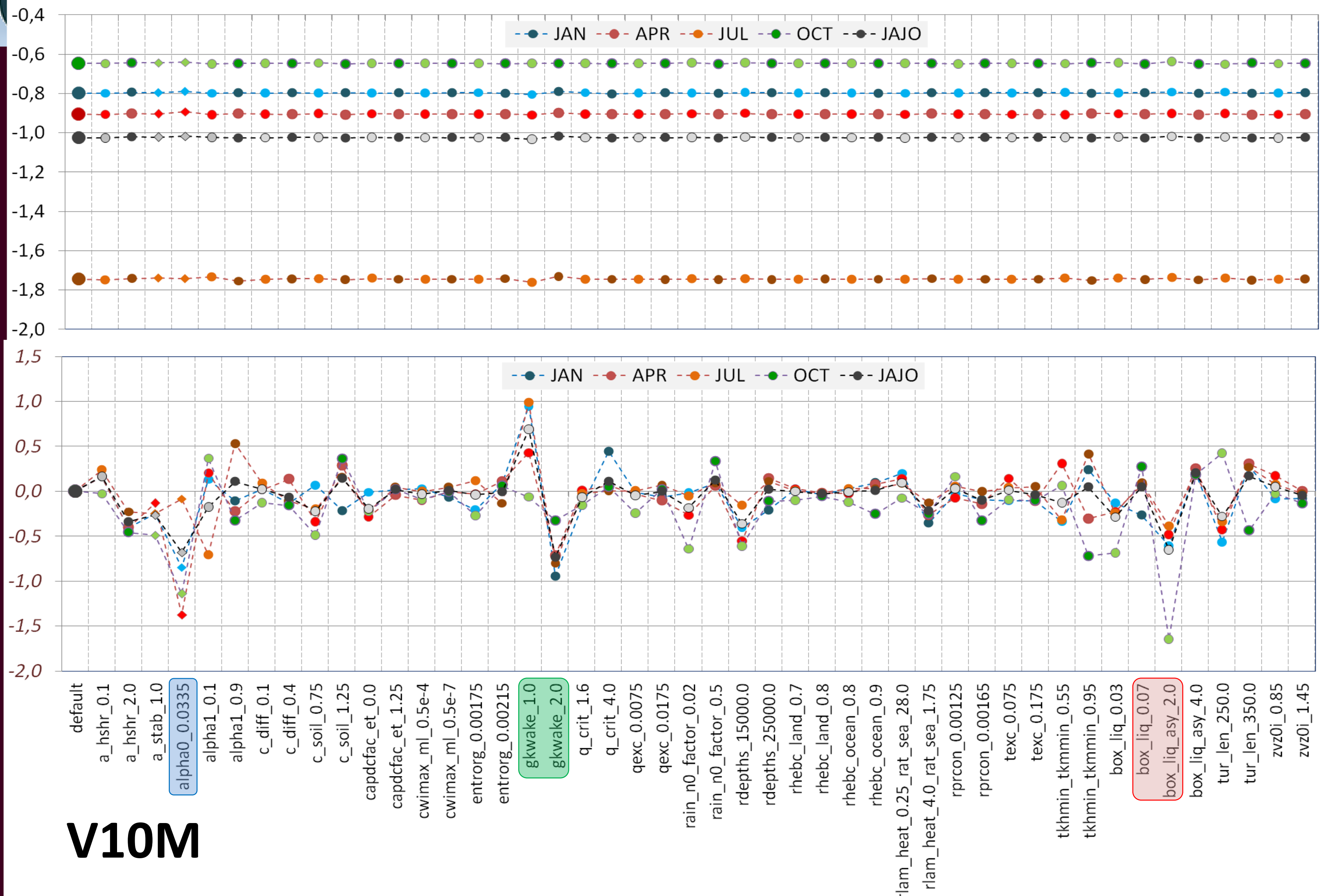
0,7
0,6
0,5
0,4
0,3
0,2
JAN APR JUL OCT JAJO
4
3
2
1
0
-1
-2
-3
-4
-5
JAN APR JUL OCT JAJO
default
a_hshr_0.1
a_hshr_2.0
a_stab_1.0
alpha0_0.0335
alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
capdcfac_et_1.25
cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
box_liq_asy_4.0
tur_len_250.0
tur_len_350.0
zvz0i_0.85
zvz0i_1.45

U10M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-1,6
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-2,0
JAN
APR
JUL
OCT
JAJO
1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
-2,0
default
a_hshr_0.1
a_hshr_2.0
a_stab_1.0
alpha0_0.0335
alpha1_0.1
alpha1_0.9
c_diff_0.1
c_diff_0.4
c_soil_0.75
c_soil_1.25
capdcfac_et_0.0
capdcfac_et_1.25
cwimax_ml_0.5e-4
cwimax_ml_0.5e-7
entrorg_0.00175
entrorg_0.00215
gkwake_1.0
gkwake_2.0
q_crit_1.6
q_crit_4.0
qexc_0.0075
qexc_0.0175
rain_n0_factor_0.02
rain_n0_factor_0.5
rdepths_15000.0
rdepths_25000.0
rhebc_land_0.7
rhebc_land_0.8
rhebc_ocean_0.8
rhebc_ocean_0.9
rlam_heat_0.25_rat_sea_28.0
rlam_heat_4.0_rat_sea_1.75
rprcon_0.00125
rprcon_0.00165
texc_0.075
texc_0.175
tkhmin_tkmmin_0.55
tkhmin_tkmmin_0.95
box_liq_0.03
box_liq_0.07
box_liq_asy_2.0
box_liq_asy_4.0
tur_len_250.0
tur_len_350.0
zvz0i_0.85
zvz0i_1.45

V10M

Most sensitive parameters for the considered fields gauged from red to blue

	clch	clcl	clcm	clclt	gust_10m	pmsl	T2m	Td2m	Tmax_2m	Tmin_2m	Tot_prec	tqc	tqi	tqv	u10m	v10m
a_hshr																
a_stab																
alpha0																blue
alpha1		blue		blue				red			blue			red		
c_diff																
c_soil							green	green	green	blue						
capdcfac																
cwimax_ml																
entrorg	green		blue													
gkwake					red	blue									green	green
q_crit												green				
qexc																
rain_n0_factor																
rdepths			blue													
rhebc_land																
rhebc_ocean																
rlam_heat_rat_sea										green	green					
rprcon	blue												green			
texc																
tkhmin_tkmmin										red				blue		
box_liq		green	green	green		green	blue		blue							
box_liq_asy	blue	red	red	red	green	red	red	blue	red		red	red	blue	green	red	red
tur_len					blue			blue	blue			blue			blue	
zvz0i	red												red			

Most sensitive parameters for the fields for which direct observations exist

	pmsl	T2m	Td2m	Tmax_2m	Tmin_2m	Tot_prec	u10m	v10m
a_hshr								
a_stab								
alpha0								
alpha1								
c_diff								
c_soil								
capdcfac								
cwimax_ml								
entrorg								
gkwake								
q_crit								
qexc								
rain_n0_factor								
rdepths								
rhebc_land								
rhebc_ocean								
rlam_heat_rat_sea								
rprcon								
texc								
tkhmin_tkmmin								
box_liq								
box_liq_asy								
tur_len								
zvz0i								

Most sensitive parameters for the “ most standard ” meteorological fields

	T2m	Td2m	Tmax_2m	Tmin_2m	Tot_prec
a_hshr					
a_stab					
alpha0					
alpha1		(red)			(blue)
c_diff					
c_soil	(green)	(green)	(green)	(blue)	
capdcfac					
cwimax_ml					
entrorg					
gkwake					
q_crit					
qexc					
rain_n0_factor					
rdepths					
rhebc_land					
rhebc_ocean					
rlam_heat_rat_sea				(green)	(green)
rprcon					
texc					
tkhmin_tkmmin				(red)	
box_liq	(blue)		(blue)		
box_liq_asy	(red)	(blue)	(red)		(red)
tur_len					
zvz0i					

Recommended list of the parameters optimized and/or perturbed

	T2m	Td2m	Tmax_2m	Tmin_2m	Tot_prec
alpha1					
c_soil					
rlam_heat_rat_sea					
tkhmin_tkmmin					
box_liq					
box_liq_asy					
tur_len					

Conclusions and prospects:

- The impact for the minimum and maximum values for most of the parameters turned out to be important for the considered meteorological fields, in reference to their default values and to their seasonal dependence .
- The sensitivity was quite versatile justifying the choice to examine directly a very large number of parameters, probably one of the largest ever in a NWP model. **However a set 7-9 parameters looks like displaying distinguished sensitivity regarding standard meteorological fields i.e. T, TD, PRECI, PMSL and U10M.**
- Due to the inclusion of a large and complicated marine area in the desired integration domain (i.e. the whole Mediterranean) for the proposed ICON-LEPS, the project is expected to provide significant and lasting advancements in the Mediterranean area .
- Work is in progress under the goal to extend the effort over the whole 2020 year (a frantic race due to the migration of ECMWF supercomputer system and equivalent of two centuries of model runs ….) as well as a subsequent comparison with observations.
- The advancement towards ICON-LEPS is expected to be a formidable operational but also research challenge for the years to come that might have also some impact model to ICON model overall.