Design and Evaluation of Sensitivity Tests for CALMO Project

E. Avgoustoglou

Hellenic National Meteorological Service

17th COSMO General Meeting, Wroclaw Poland

September 7 2015

WORK OVERVIEW

- The goal of this effort is to gauge the sensitivity of COSMO model over a number of expected relatively high impact parameters.
- The reference are the works of Bellprat *etal* towards the optimization of CLM through the realistic implementation of a metamodel.
- The list of the parameters was decided by CALMO working group over extensive communication and recommendations from COSMO experts.
- The parameters were tested over the wider Mediterranean area for a period of 62 dates from February, June, and December of 2013 with an emphasis over Switzerland.

SENSITIVITY TESTS BLUEPRINT

13 parameters were considerd.

⊗

3 values/parameter including default.

⊗

The evaluation period consisted of 62 days from year 2013, i.e.: February 1-20, June 1-20, December 10-31.

=

2418 runs based on COSMO.v5.0

- Horizontal grid size: 0.0625^0 (~7km).
- 649x393 grid points (wider mediterranean area), 60 levels.
- Integration time-step: 30 secs.
- Integration period: 48 hs.
- Boundary conditions : 6hr IFS Analysis.
- Computational Cost ~ 10^7 b.u. on Cray X C30 of ECMWF (gratis HNMS).

DESCRIPTION OF PARAMETER LIST

PARAMETER	INTERPRETATION	RANGE	TEST VALUES (default)
a_stab	factor for stability correction of horizontal length scale	0.0 – 1.0	0.0 , 0.5, 1.0
crsmin	minimum stomatal resistance	50-300	50, 150, 300
c_soil	surface area index of evaporative soil surfaces (dependent on surface area density of the roughness elements over land , c_lnd)	0-c_lnd(2.0)*	0, 1, 2
entr_sc	mean entrainment rate for shallow convection	5.0E-5 – 2.0E-3	5.0E-5, 3.0E-4, 2.0E-3
mu_rain	shape parameter of the rain drop size distribution (max value set equal to 2 for COSMO.V5.0	0 – 2	0,1,2
q_crit	critical value for normalized oversaturation	1.0 – 4.0	1.6, 2.8, 4.0
qi0 **	cloud ice threshold for autoconversion (tentative validity if different than 0)	0-0.01	0, 0.005, 0.01
rain_n0_factor	factor to reduce the evaporation of raindrops	0.02 - 5.0	0.02, 1.0, 5.0
rat_sea	ratio of laminar scaling factors for heat over sea	1-100	10, 20, 100
rlam_heat	scaling factor of the laminar boundary layer for heat	0.1 – 2.0	0.1, 1.0, 2.0
tkhmin tkmmin	minimal value of diffusion coefficient for heat and momentum (kept equal)	0.1-1.0	0.1, 0.4, 1.0
tur_len	asymptotic maximal turbulent length scale (m)	100 – 1000	100, 150, 1000
v0snow	factor in the terminal velocity for snow	10.0 – 30.0	10, 20, 30

* c_lnd: Surface-area index of gridpoints over land (excluding leaf-area index).

** The «gray» variable **qi0**, although its sensitivity will be shown, it is not accounted at this stage of our work due to caution regarding its use if different than its default value (communication with Axel Seifert).

INVESTIGATED VARIABLES (AREA AVERAGES)

- **< TMAX2m >:** Maximum 2m temperature for 0-24 hr periods.
- **< TMIN2m >:** Minimum 2m temperature 0-24 hr periods.
- **< TOTPREC >:** 0-24 hr period accummulated precipitation (kg m^{-2}).
- **< SNOW_GSP >:** 0-24 hr periods accumulated grid-scale snow (kg m^{-2})
- **< CLCL >:** Low cloud cover (%) average of 3hr time steps 03-24 hs.
- **< CLCM >:** Medium cloud cover (%) average of 3hr time steps 03-24 hs.
- **< CLCH > :** High cloud cover (%) average of 3hr time steps 03-24 hs.
- **< CLCT > :** Total cloud cover (%) average of 3hr time steps 03-24 hs.

! The same investigation was performed for 24-48 hr periods with approximately the same performance.

DEFINITION OF SENSITIVITIES (S)

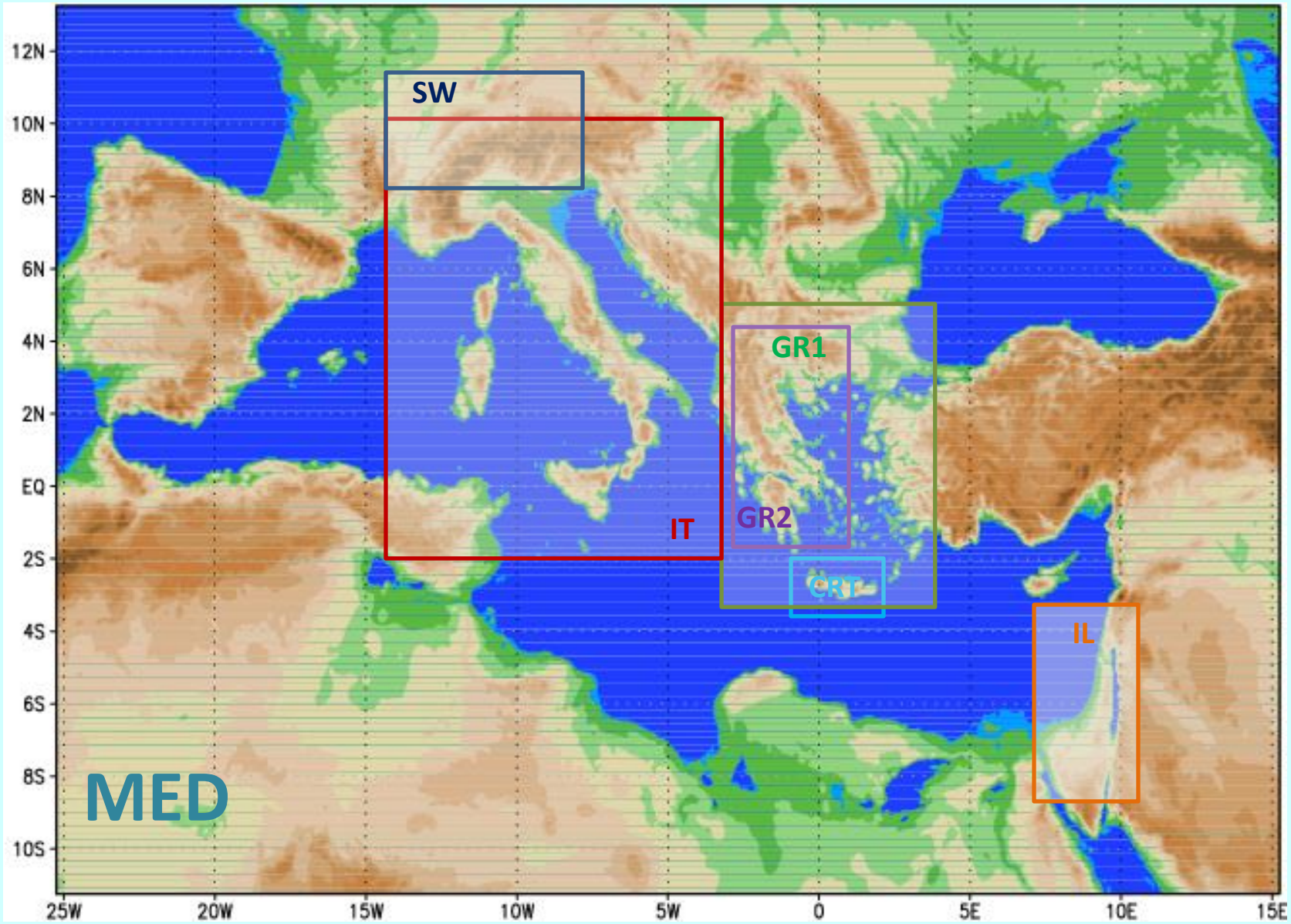
$$S_{<P>}(\%) = \frac{< P >_{TEST} - < P >_{DEFAULT}}{< P >_{DEFAULT}} \bullet 100$$

$< P >$ stands for $< SNOWGSP >$ *or* $< TOTPREC >$ *or* $< CLCL >$ *or* $< CLCM >$ *or* $< CLCH >$ *or* $< CLCT >$

$$S_{\{\langle \mathrm{TOTPREC} \rangle, \langle \mathrm{SNOWGSP} \rangle, \langle \mathrm{CLCH} \rangle, \langle \mathrm{CLCM} \rangle, \langle \mathrm{CLCL} \rangle\}} = \left|S_{\langle \mathrm{TOTPREC} \rangle}\right| + \left|S_{\langle \mathrm{SNOWGSP} \rangle}\right| + \left|S_{\langle \mathrm{CLCH} \rangle}\right| + \left|S_{\langle \mathrm{CLCM} \rangle}\right| + \left|S_{\langle \mathrm{CLCL} \rangle}\right|$$

$$S_{\begin{bmatrix} TMIN\,2m \\ TMAX\,2m \end{bmatrix}} = \begin{bmatrix} < TMIN\,2m > \\ < TMAX\,2m > \end{bmatrix}_{TEST} - \begin{bmatrix} < TMIN\,2m > \\ < TMAX\,2m > \end{bmatrix}_{DEFAULT}$$

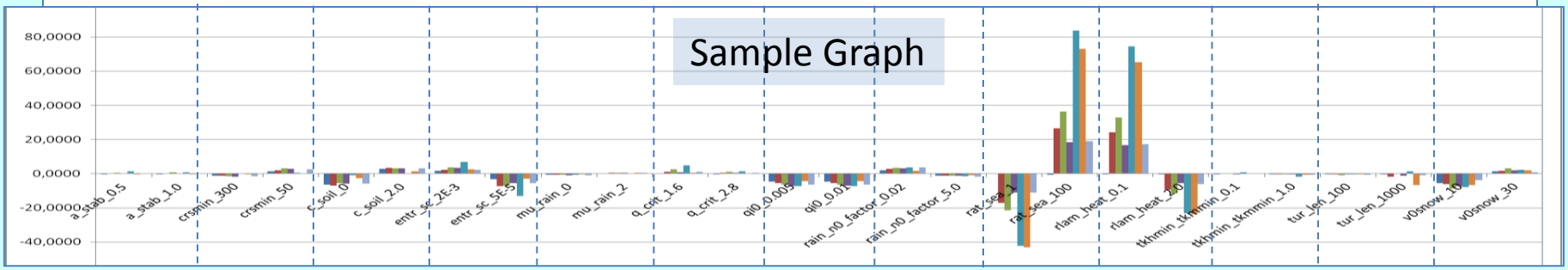
SELECTED DOMAINS



The selection was based on COSMO countries location from the SouthEast (domain IL) to the NorthWest (domain SW) in order to reveal any changes to the parameter sensitivities due to the climatic differences of the domains.

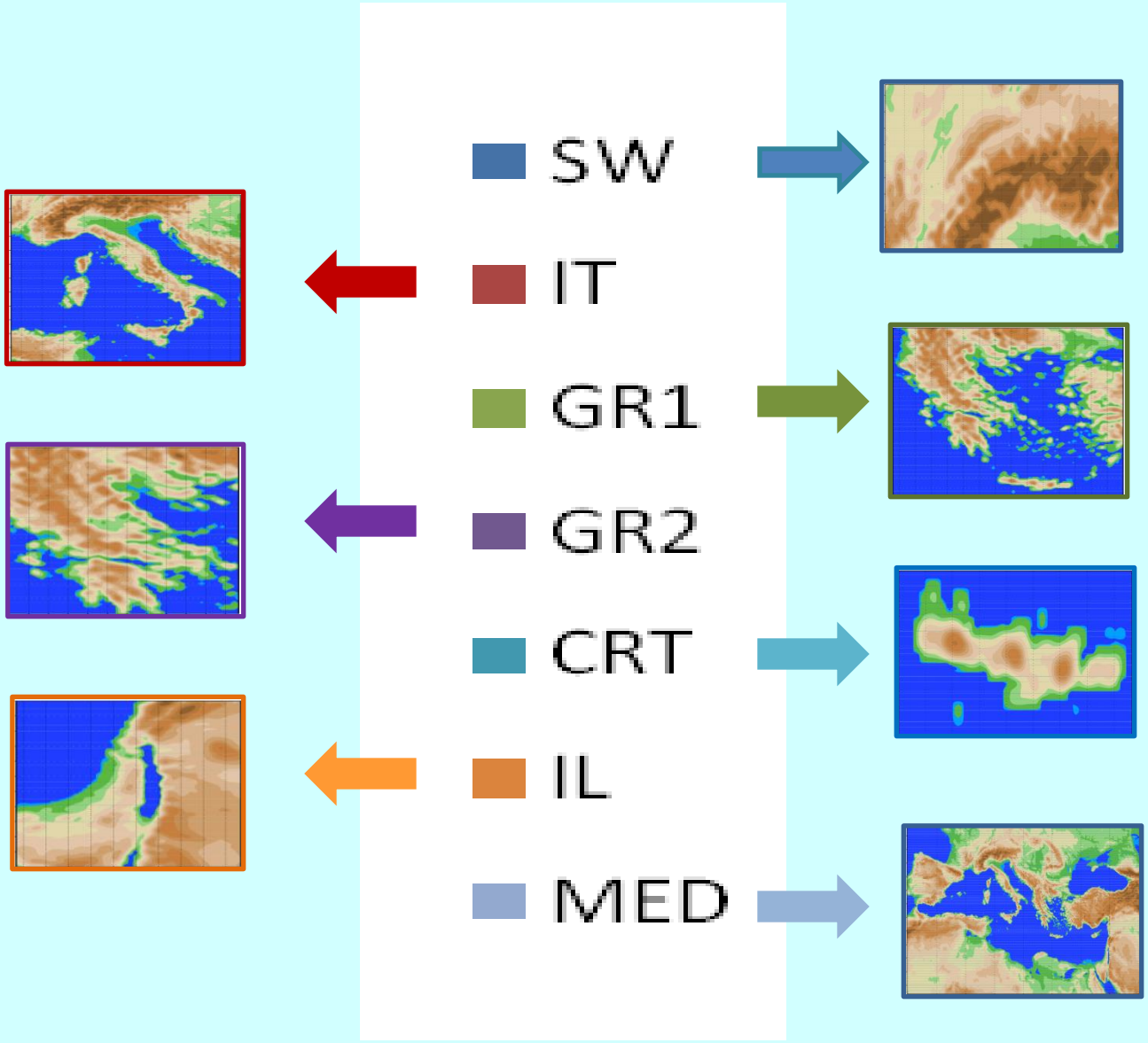
GRAPH FEATURES

- The sensitivities of the considered variables are presented for every period as well as for the total number of days in succesive clustered column graphs:
  - For all areas, i.e. SW, IT, GR1, GR2, CRT, IL, MED.
  - For SW, IT, GR1, GR2, MED.
  - For SW, IT, MED.
  - For SW, MED.
  - For SW.
- Color correspondance of the domains: SW IT GR1 GR2 CRT IL MED
- The idea behind the domain choices is to display the changes in sensitivities in reference to the relative location of the domains from the SouthEast (IL) to the NorthWest (SW) which is the focal domain of CALMO project at its present stage.
- On the horizonta axis, the sensitivities are presented for every pair of the parameter values under consideration.
- ● depicts the most sensitive parameters.
- ● depicts parameters with sensitivity of order 10% of ●.
- ● the sensitivity of **qi0** is displayed but not considered at this stage of the work



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150 ●	1 ●	3E-4 ●	1	4.0 ●	0.005 ●	1.0 ●	20 ●	1.0 ●	0.4	150 ●	20 ●

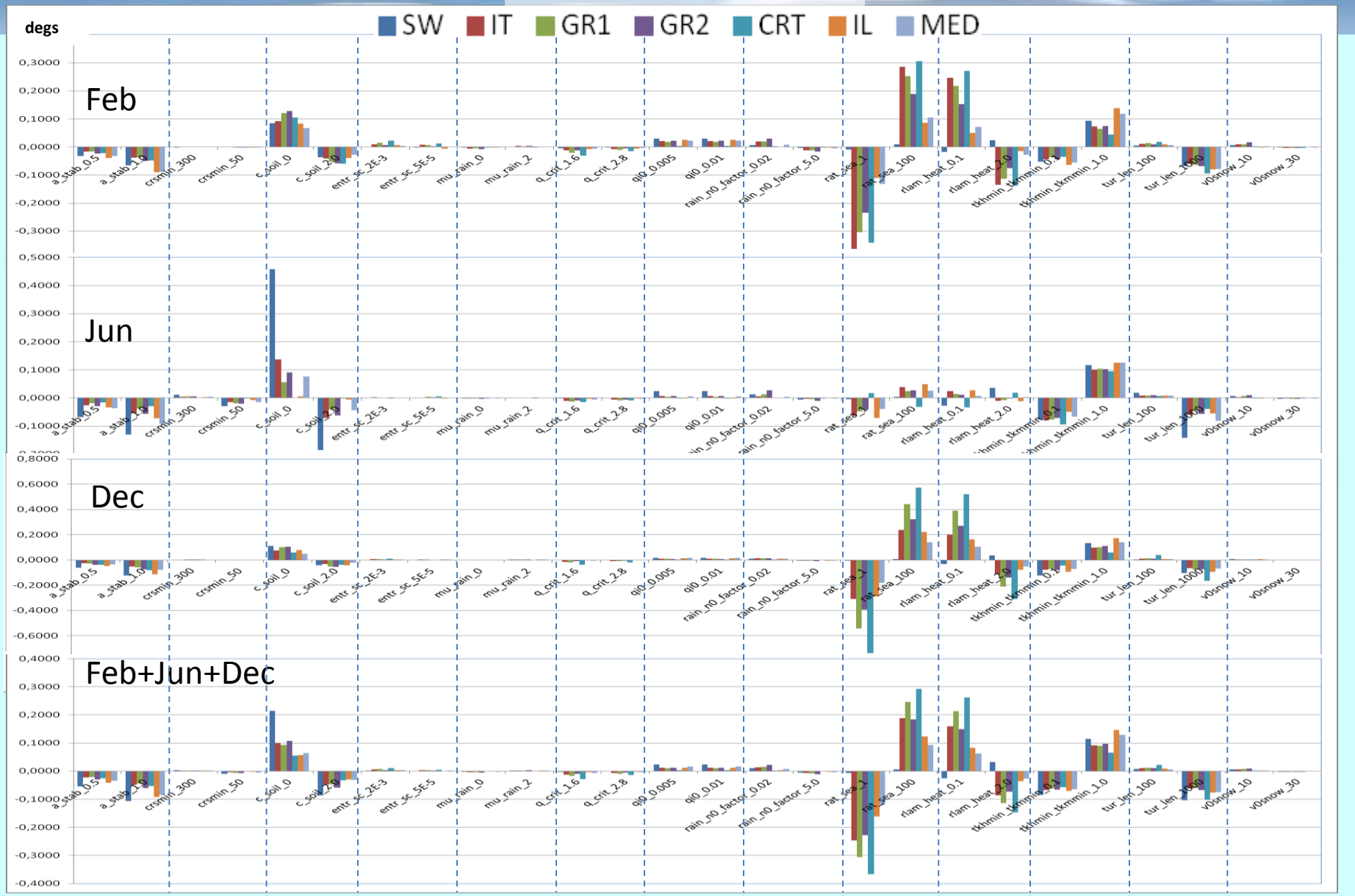
DOMAIN COLOR CORRESPONDENCE



Sensitivity (degs) for TMIN2m

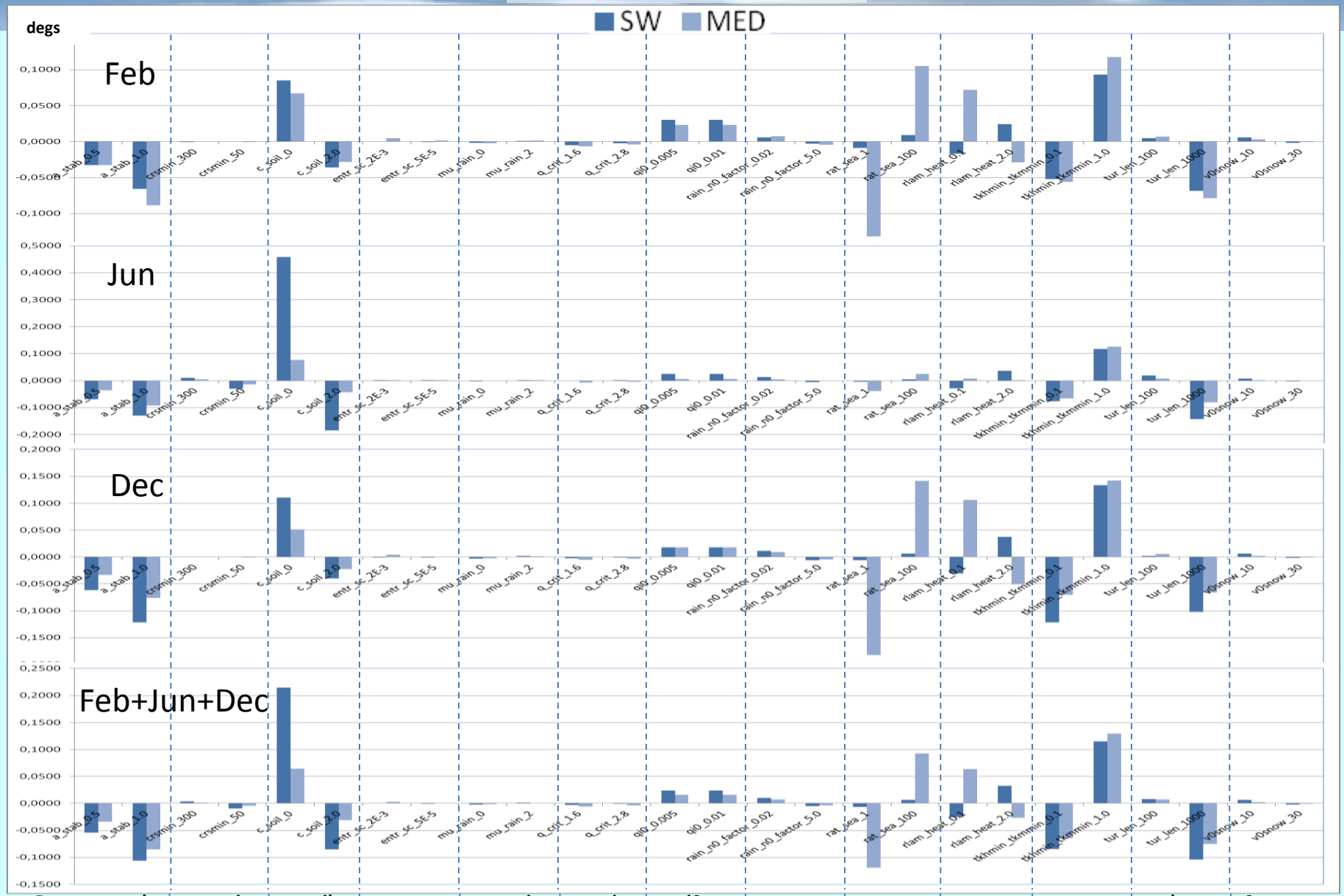
$$S_{TMIN\,2m} = \langle TMIN2m \rangle_{TEST} - \langle TMIN2m \rangle_{DEFAULT}$$

Sensitivity for TMIN2m



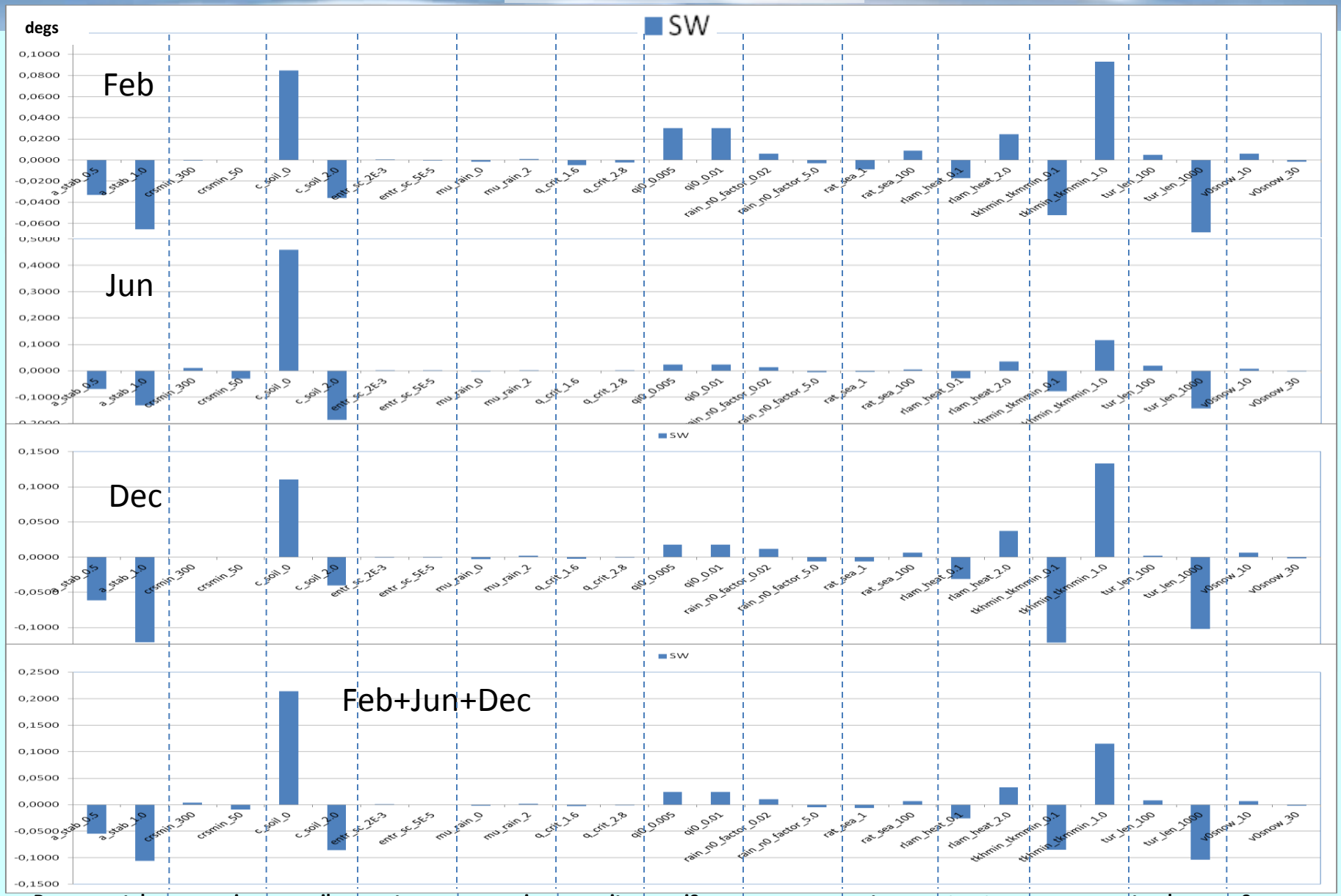
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for TMIN2m



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for TMIN2m

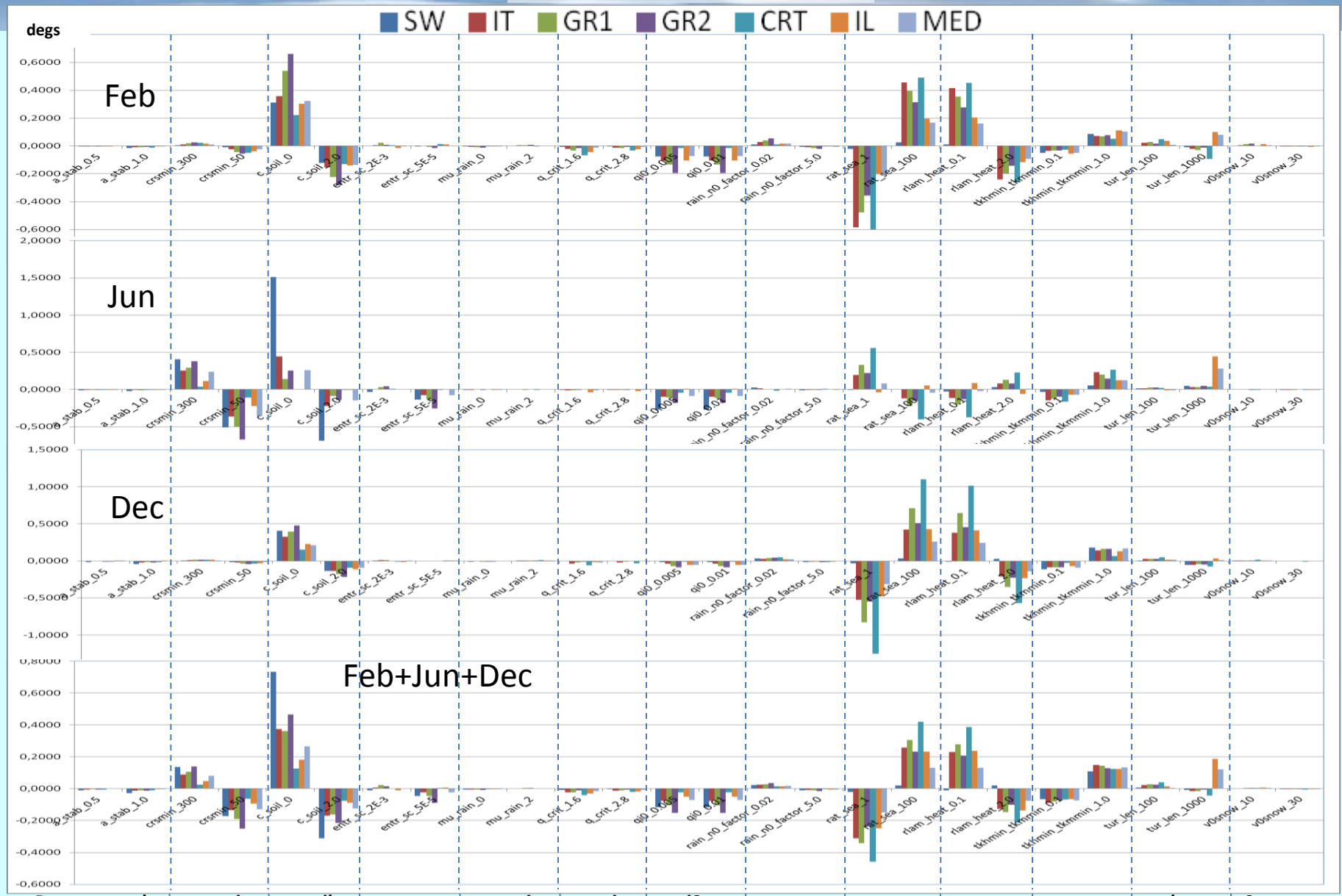


Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (degs) for TMAX2m

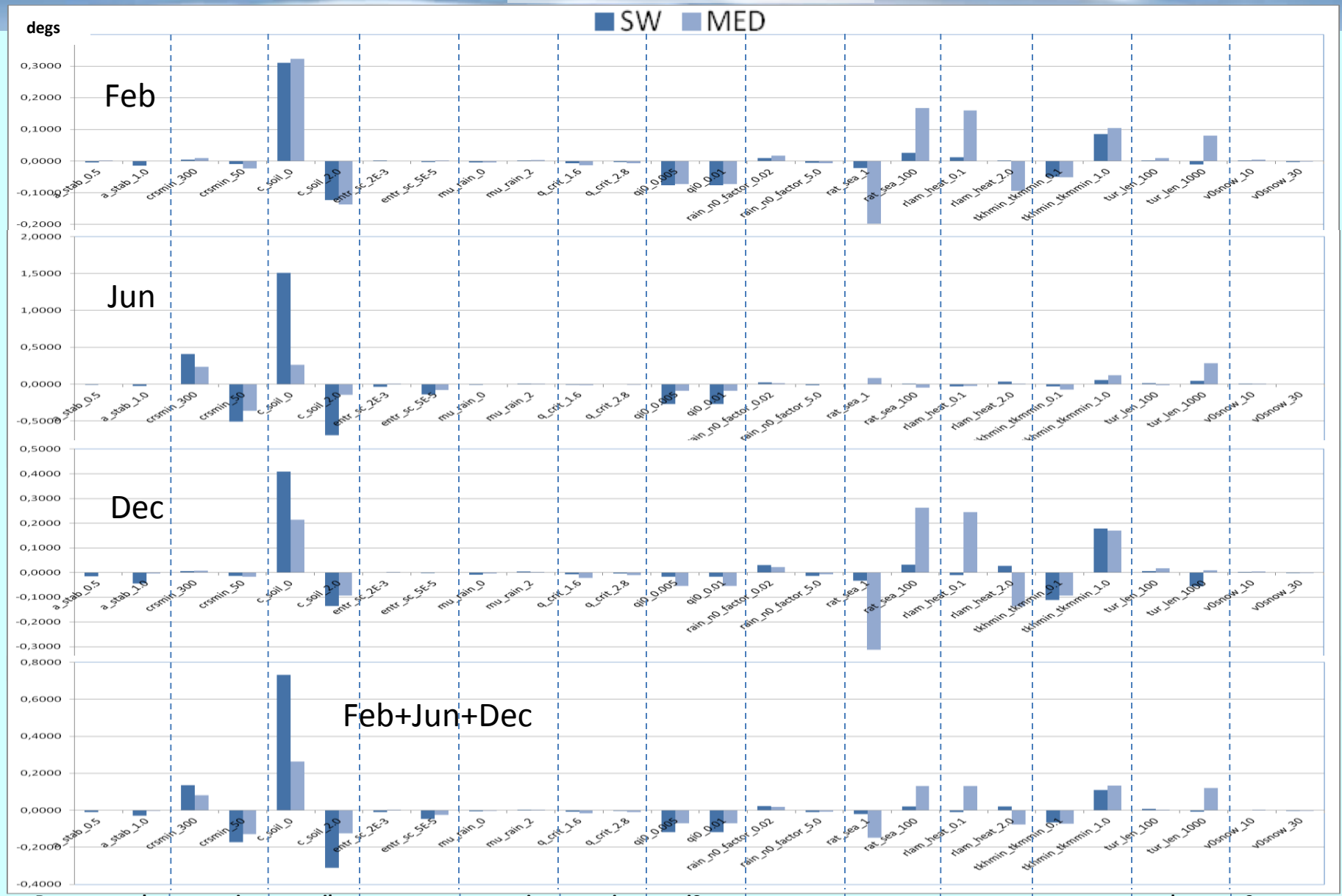
$$S_{TMAX\,2m} = \langle TMAX\,2m \rangle_{TEST} - \langle TMAX\,2m \rangle_{DEFAULT}$$

Sensitivity for TMAX2m



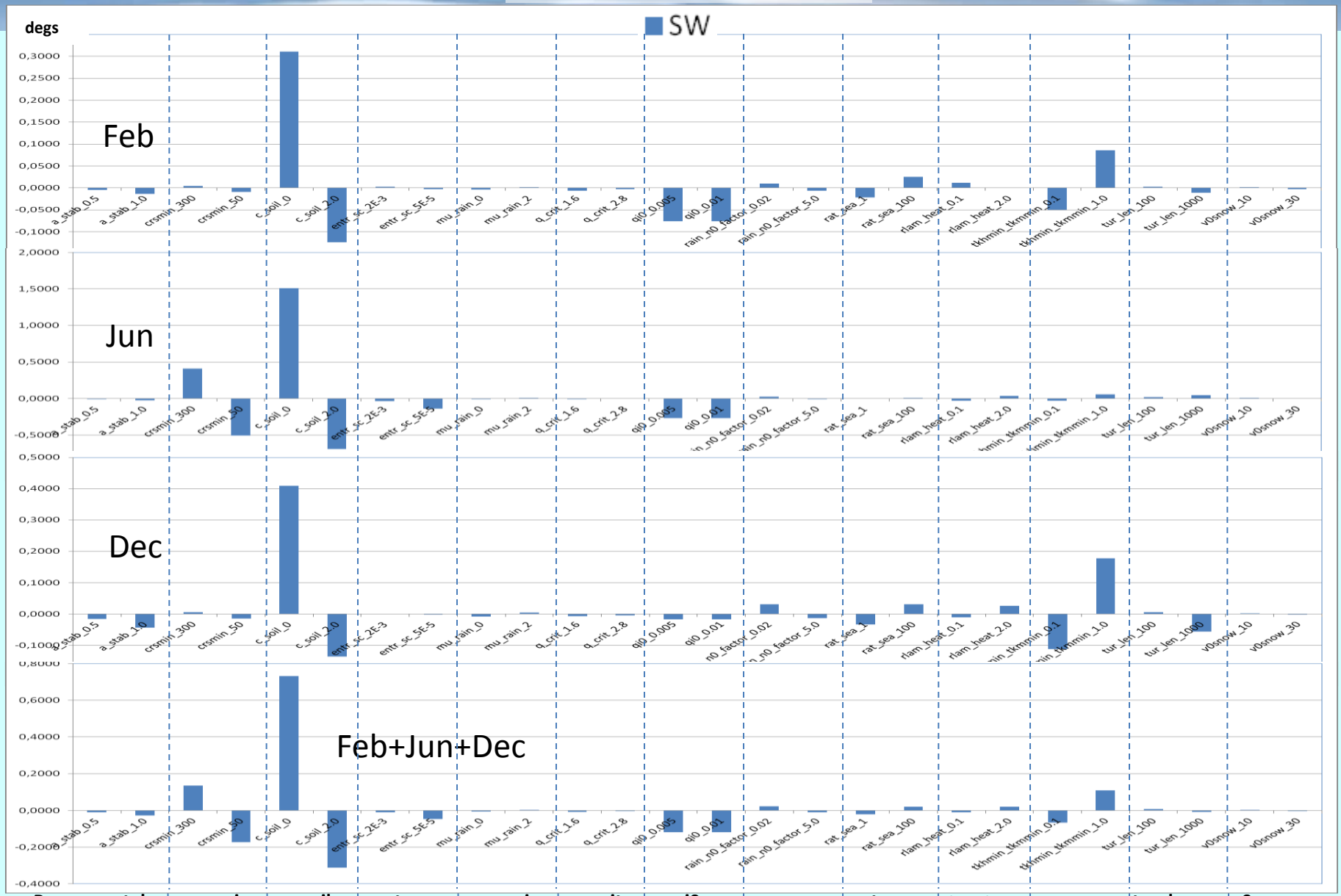
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for TMAX2m



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for TMAX2m

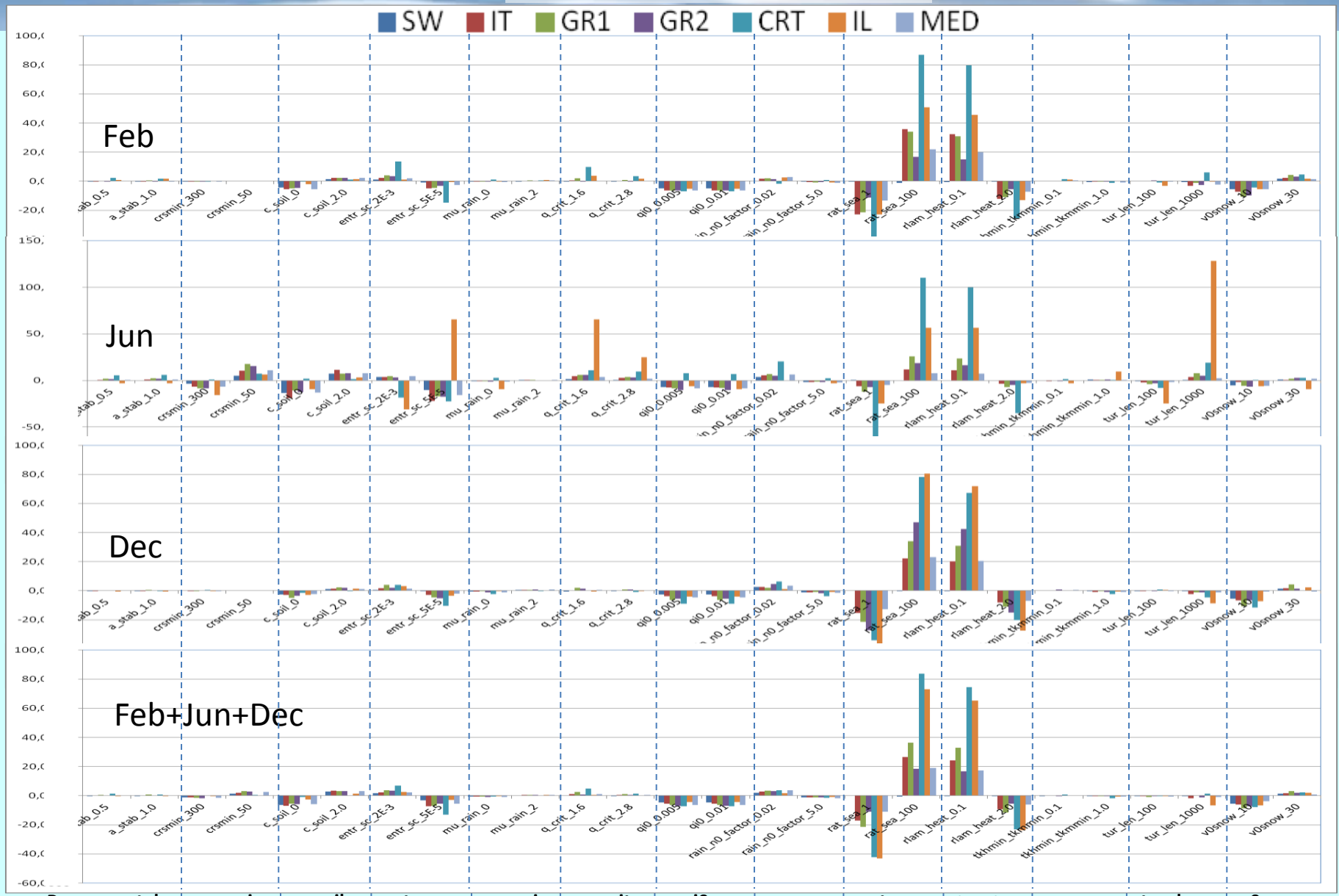


Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for TOTPREC

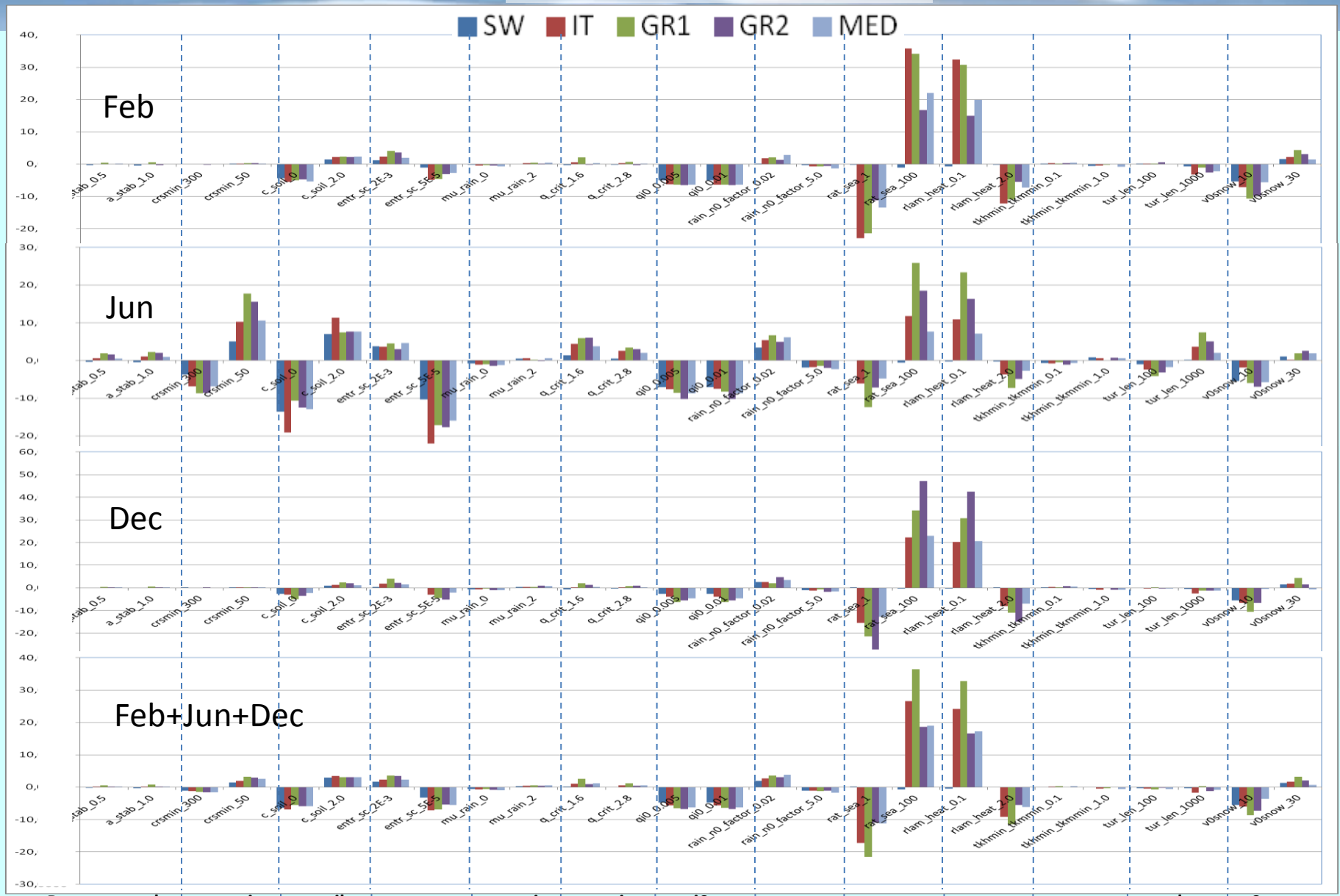
$$S_{<TOTPREC>} = \frac{< TOTPREC >_{TEST} - < TOTPREC >_{DEFAULT}}{< TOTPREC >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for TOTPREC



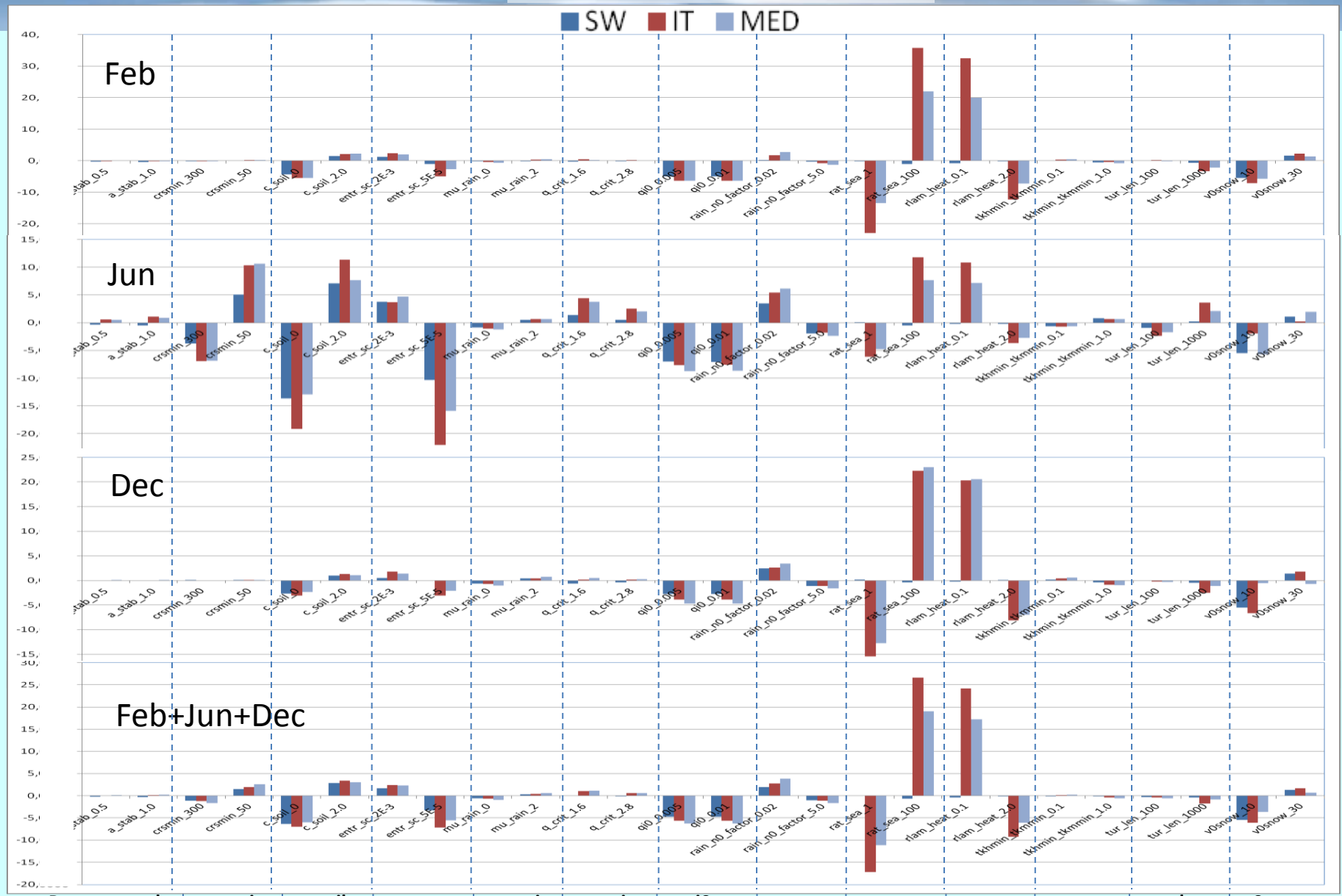
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for TOTPREC



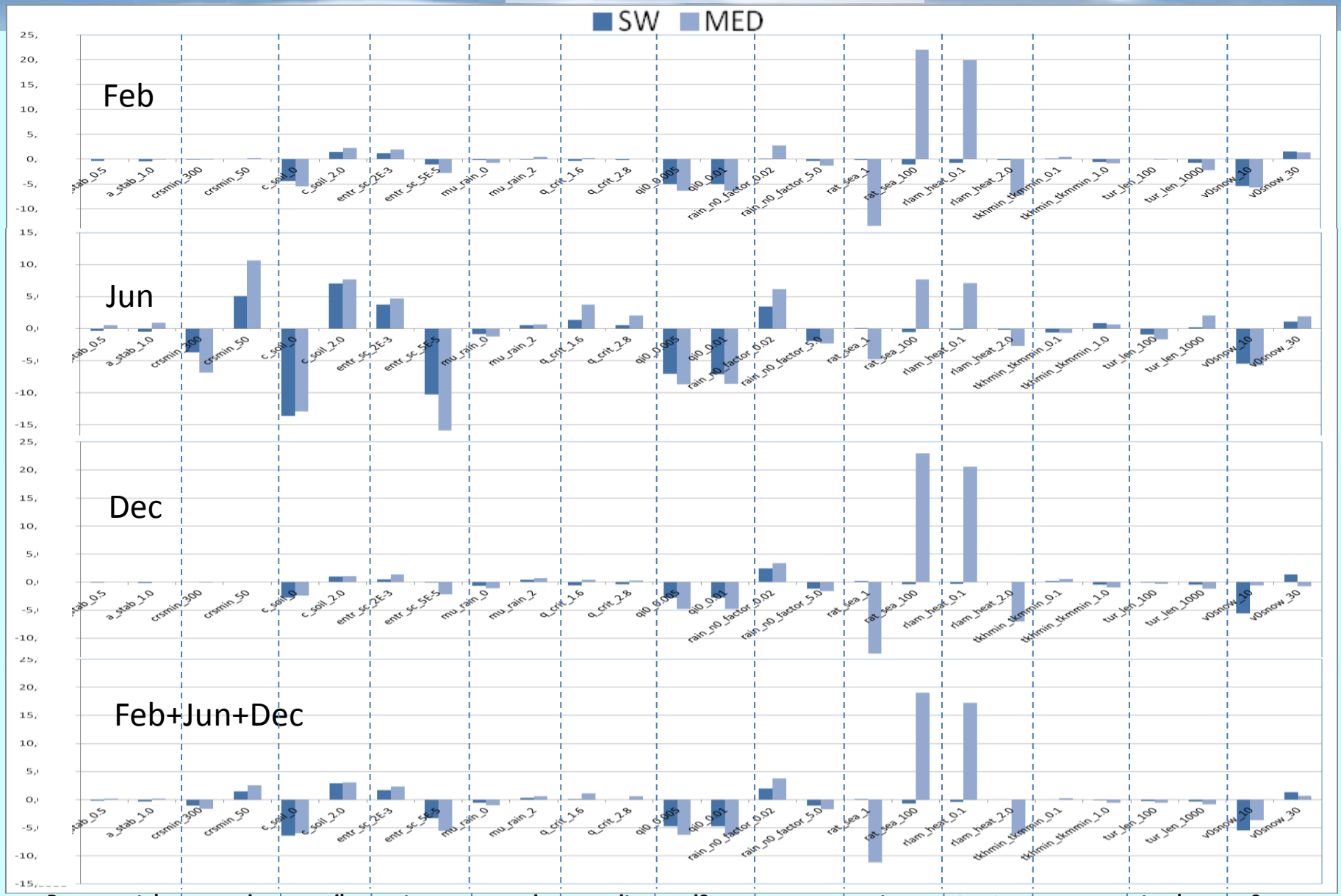
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for TOTPREC



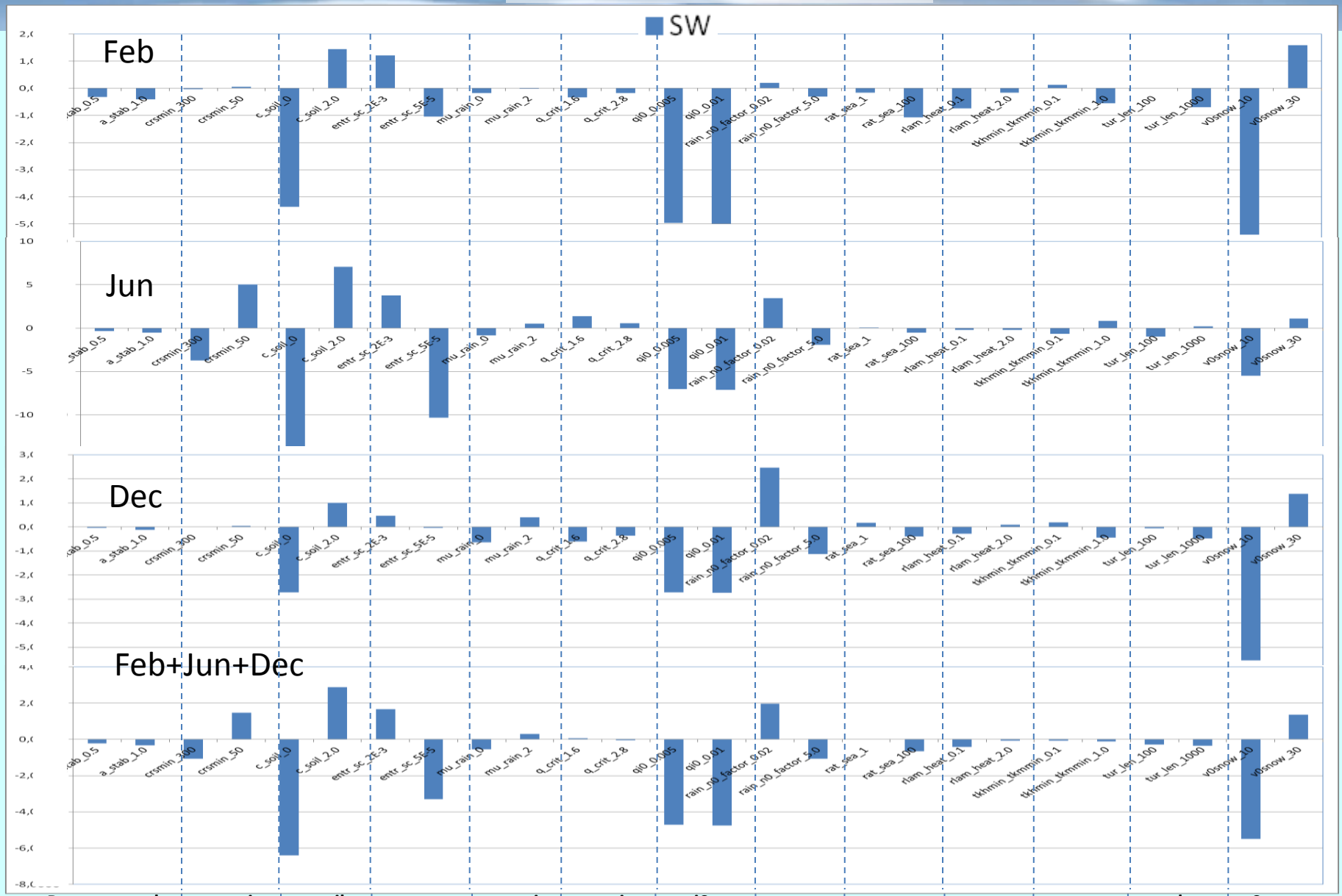
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for TOTPREC



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for TOTPREC

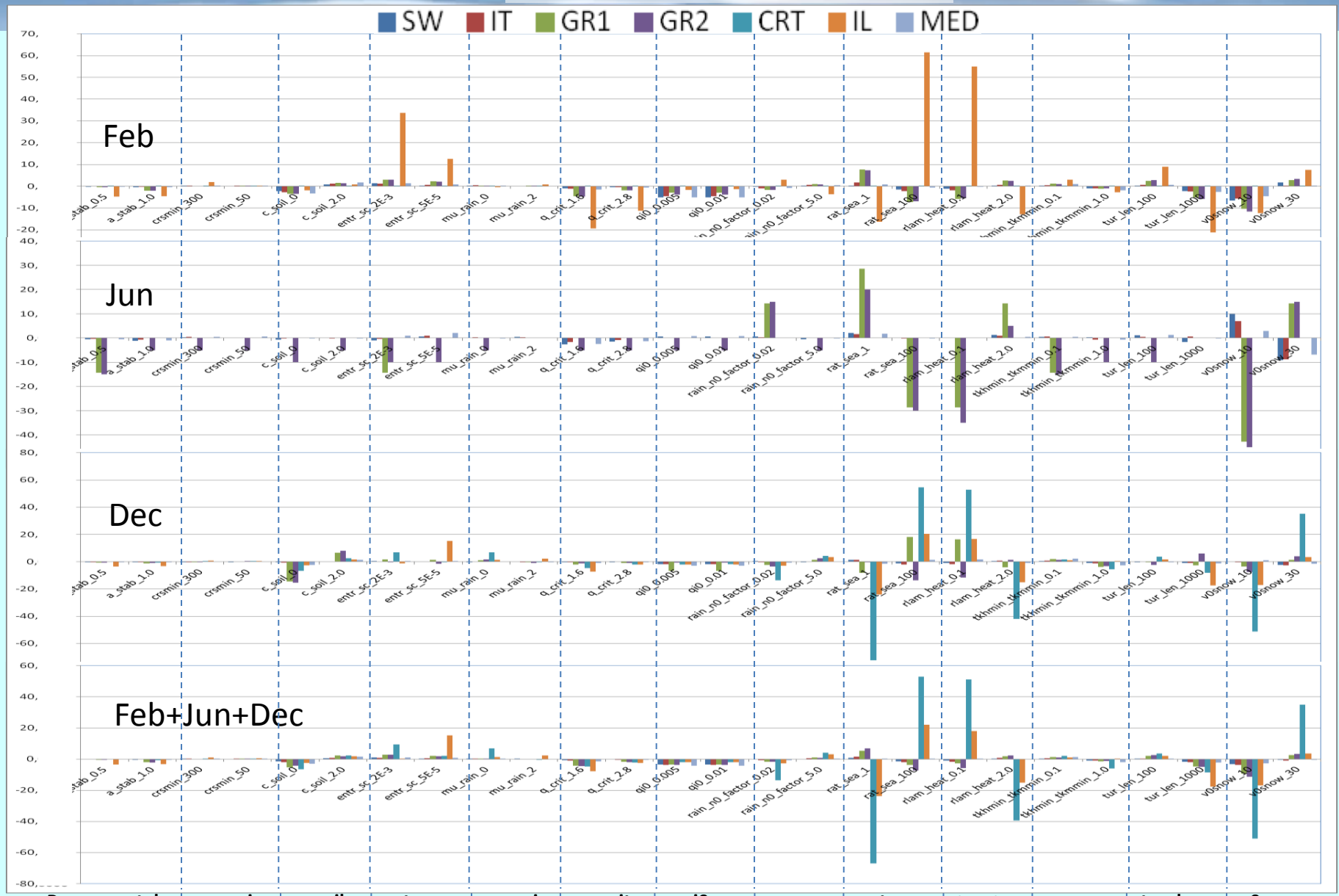


Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for SNOWGSP

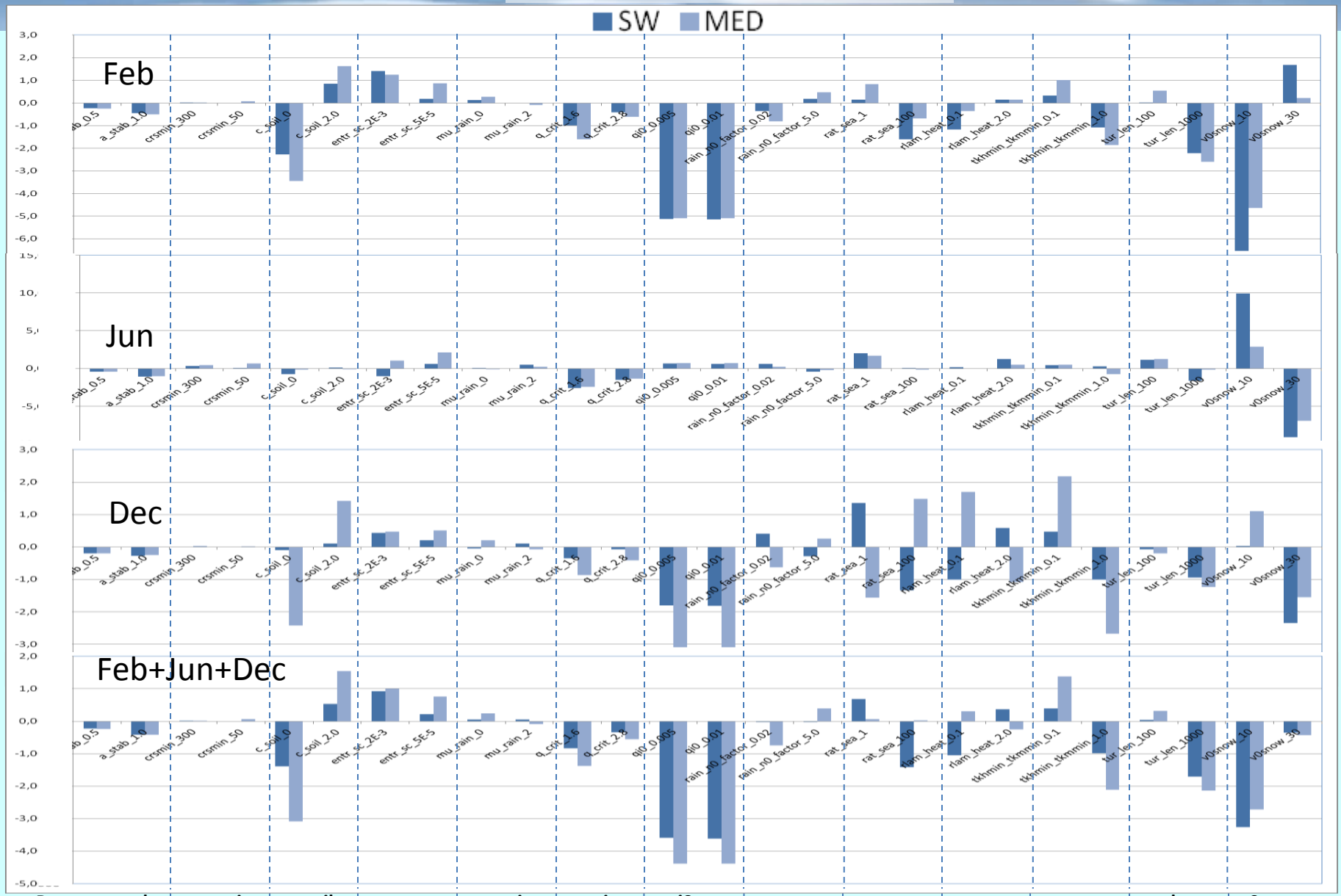
$$S_{<SNOWGSP>} = \frac{< SNOWGSP >_{TEST} - < SNOWGSP >_{DEFAULT}}{< SNOWGSP >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for SNOWGSP



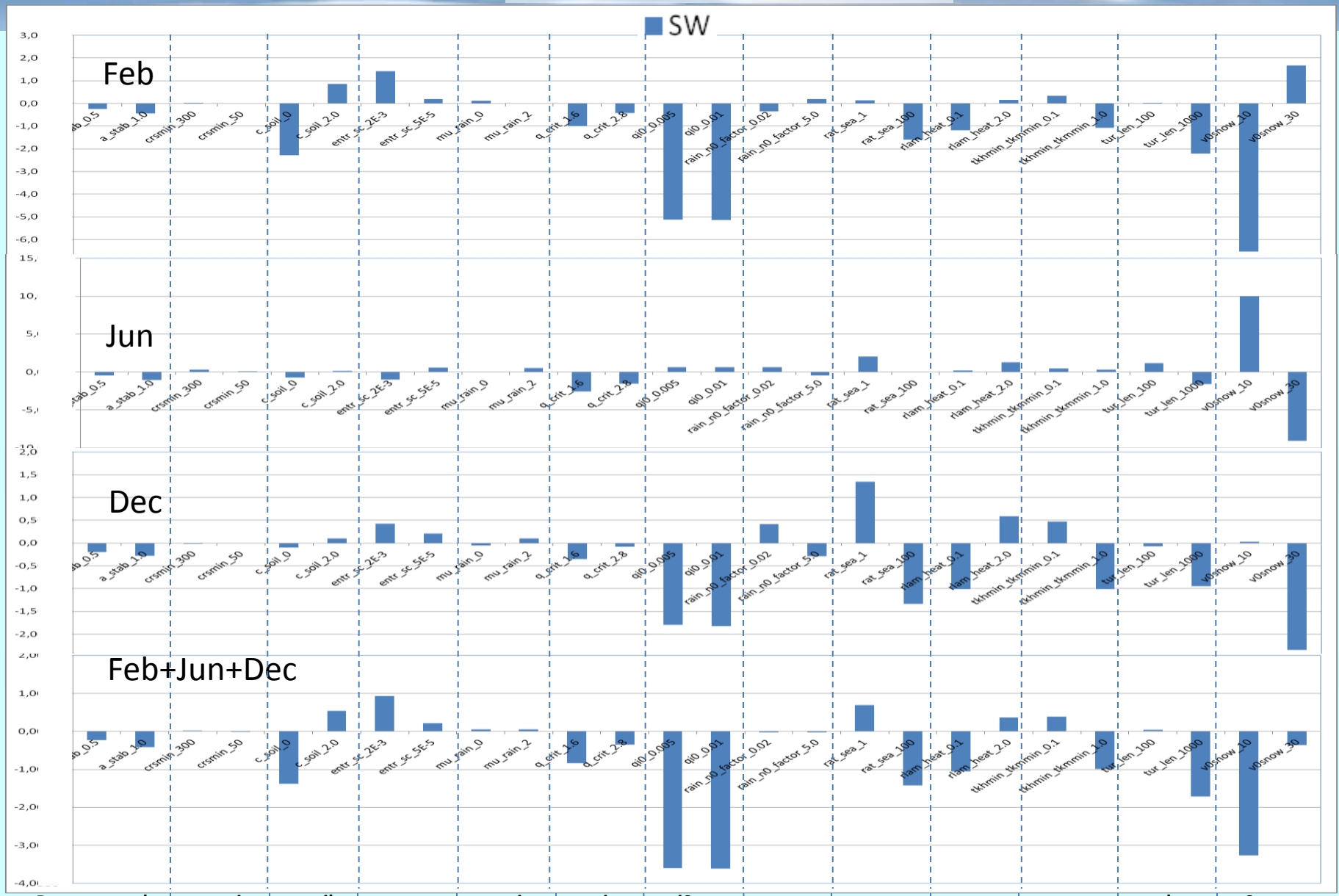
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for SNOWGSP



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for SNOWGSP



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

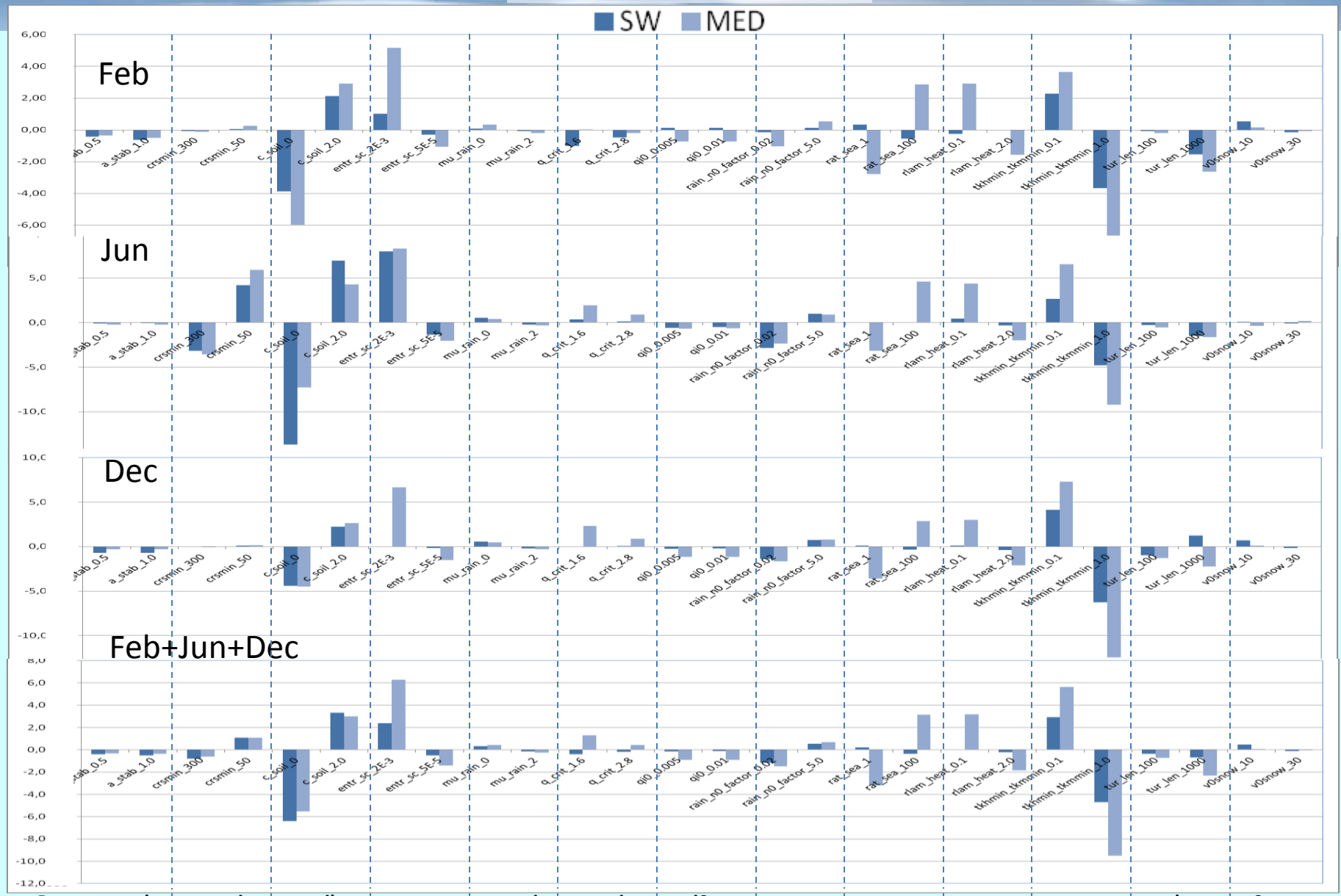
Sensitivity (%) for CLCL

$$S_{<CLCL>} = \frac{< CLCL >_{TEST} - < CLCL >_{DEFAULT}}{< CLCL >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for CLCL

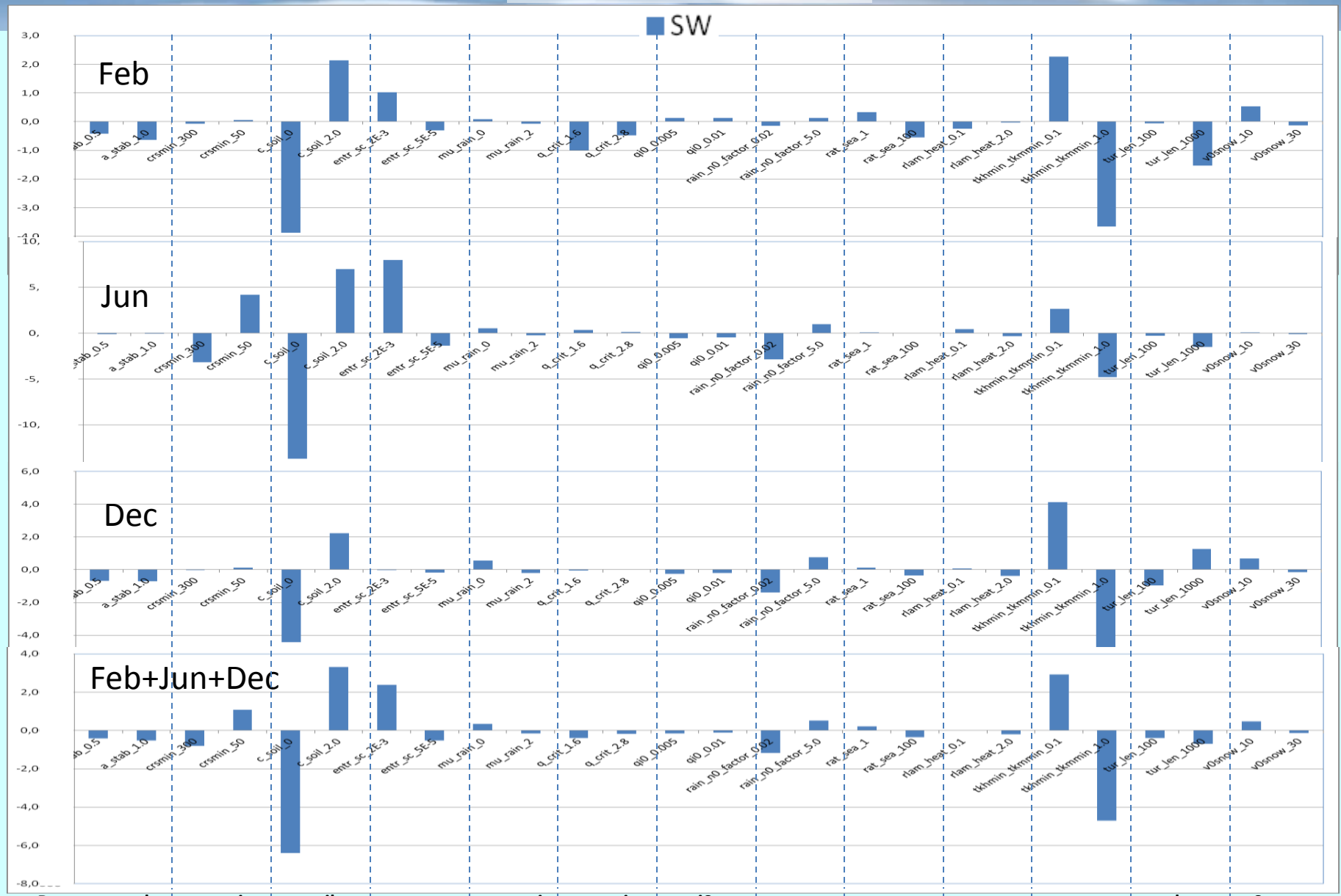
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCL



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCL

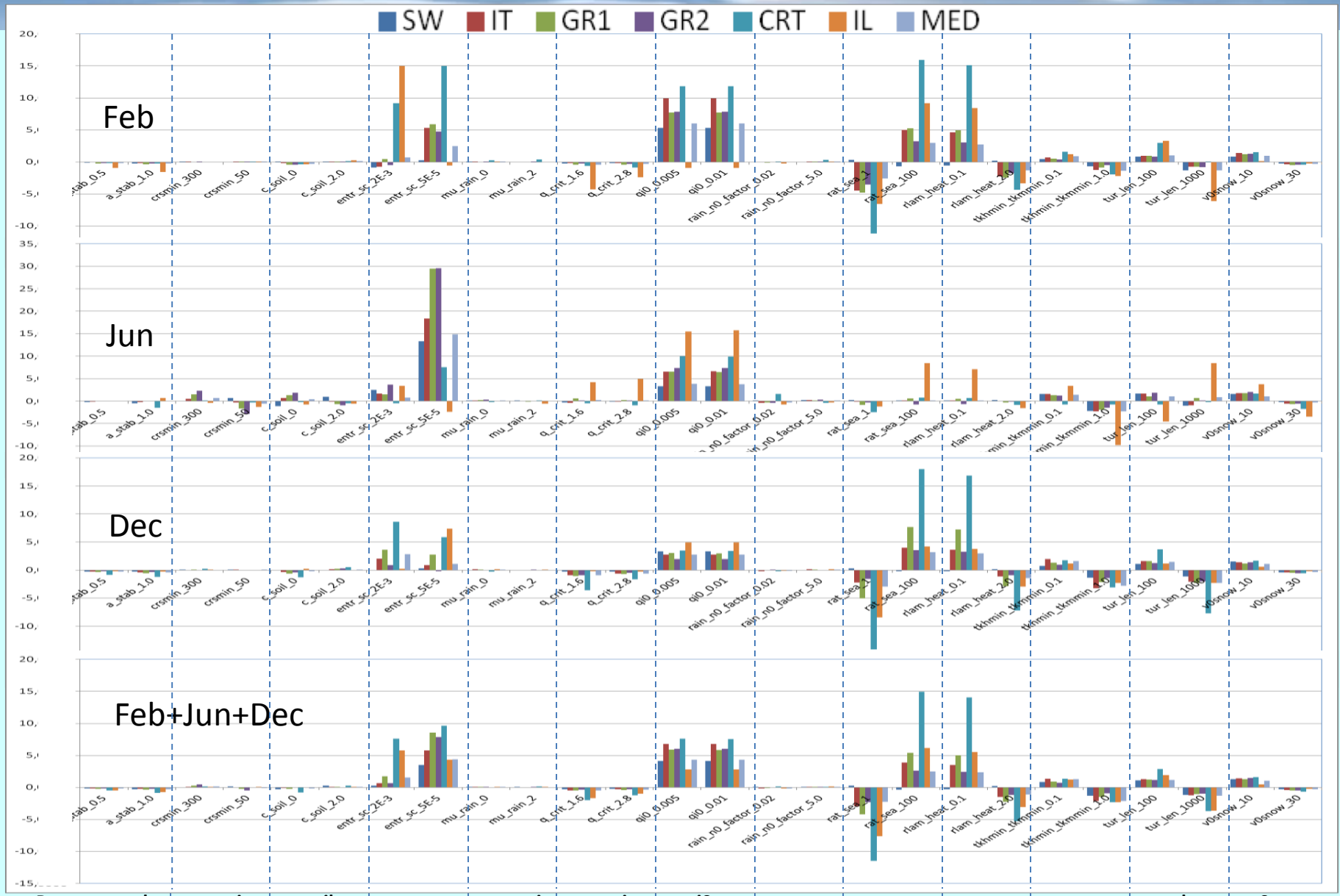


Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCM

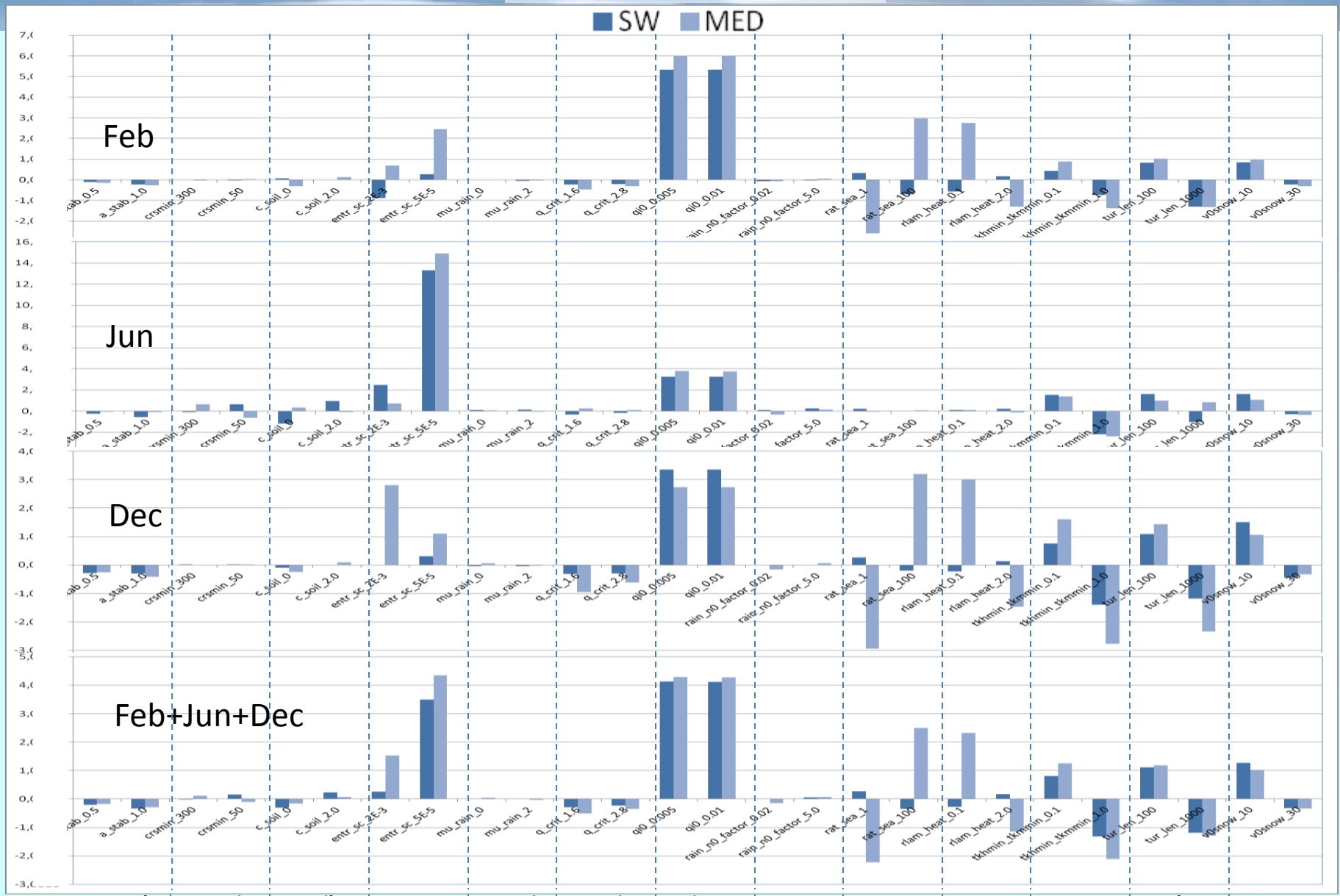
$$S_{<CLCM>} = \frac{< CLCM >_{TEST} - < CLCM >_{DEFAULT}}{< CLCM >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for CLCM



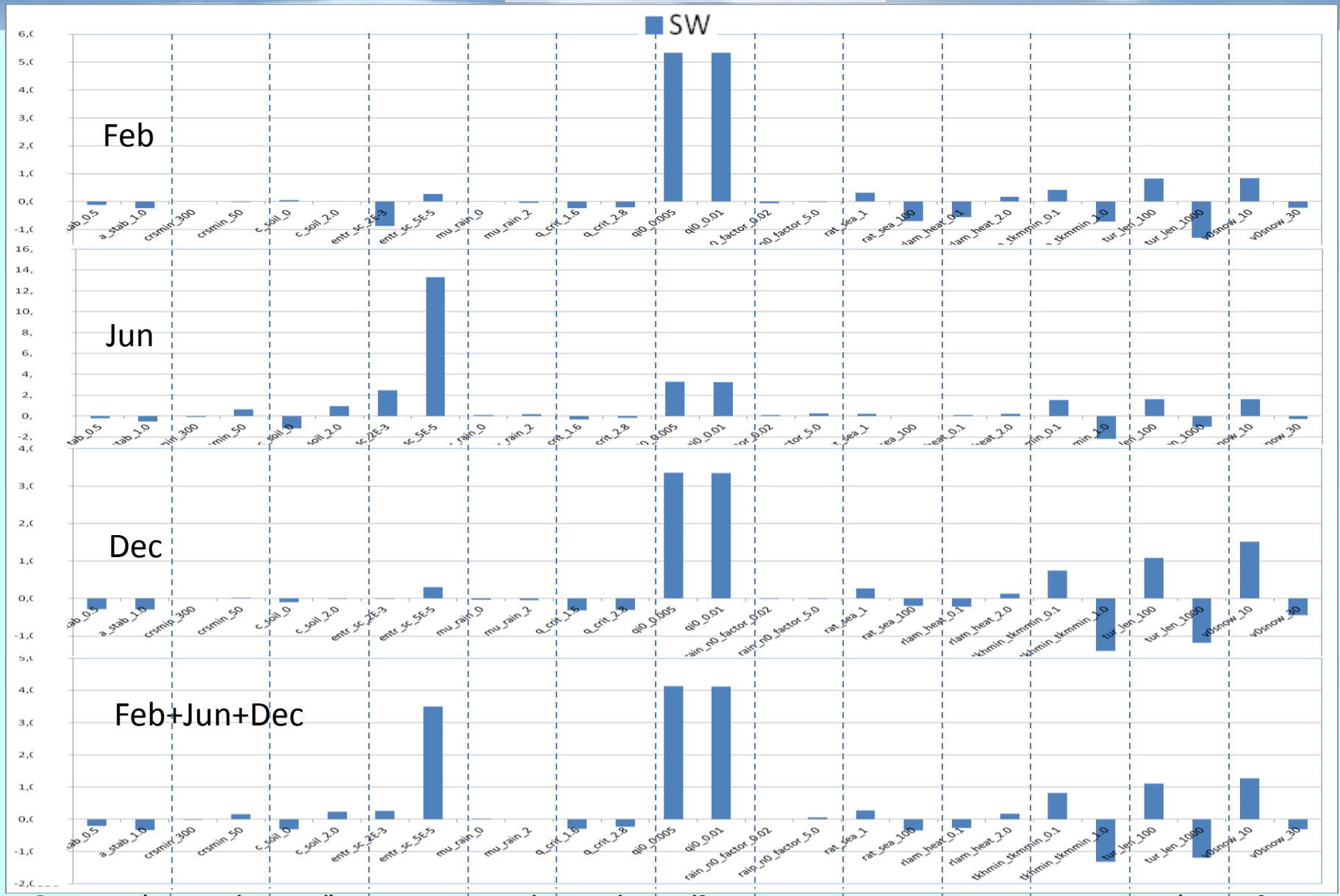
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCM



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCM

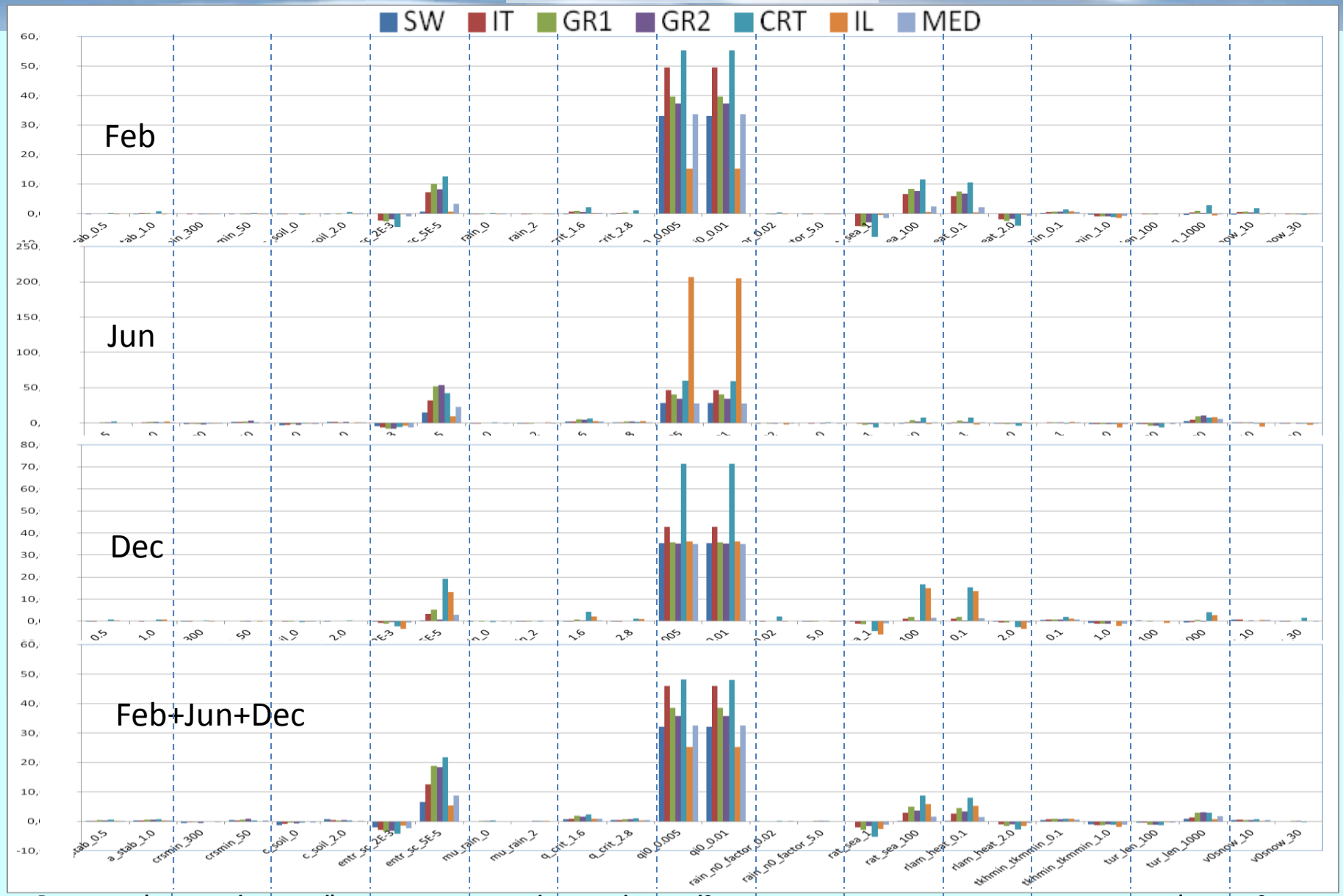


Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCH

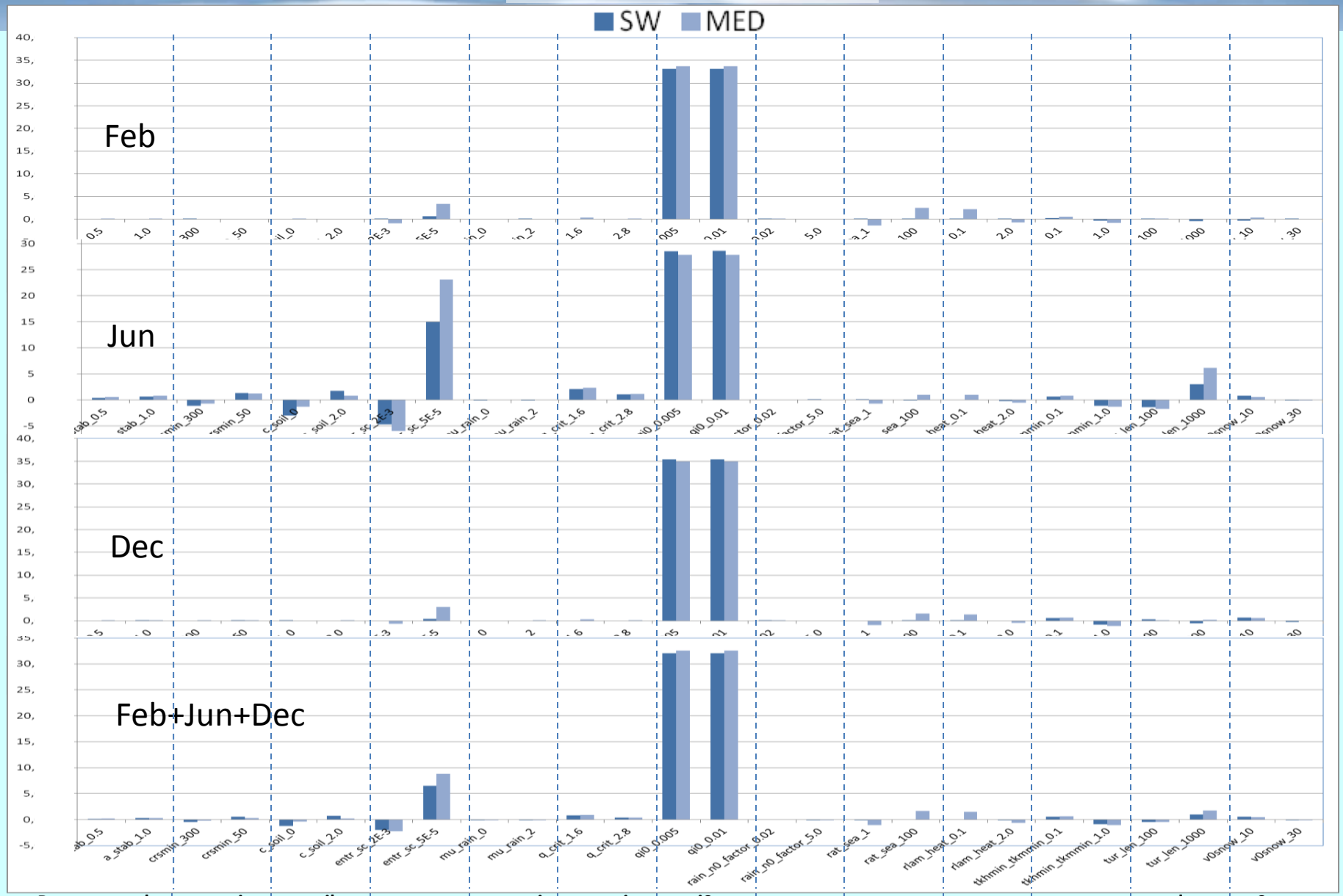
$$S_{<CLCH>} = \frac{< CLCH >_{TEST} - < CLCH >_{DEFAULT}}{< CLCH >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for CLCH



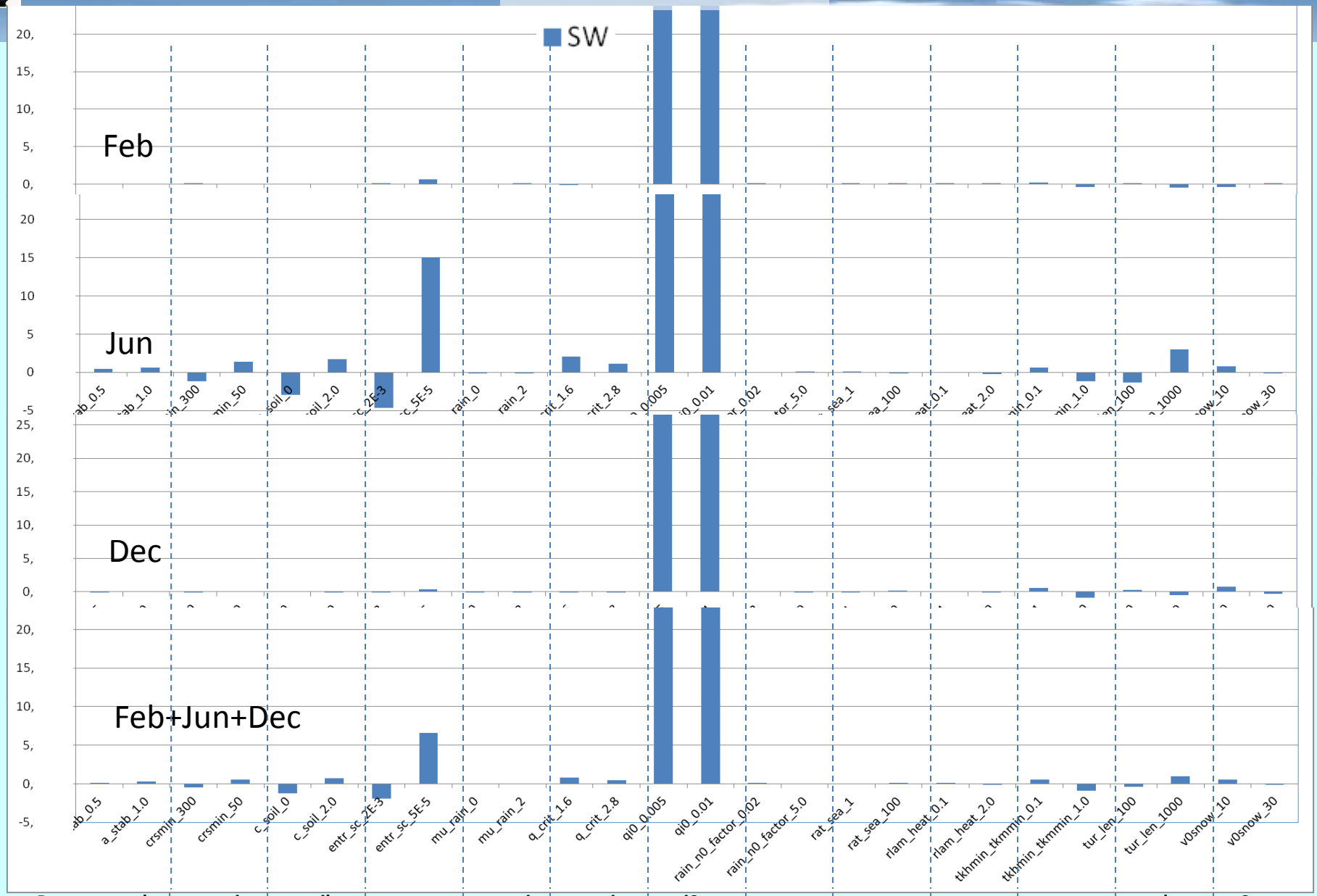
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCH



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCH



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

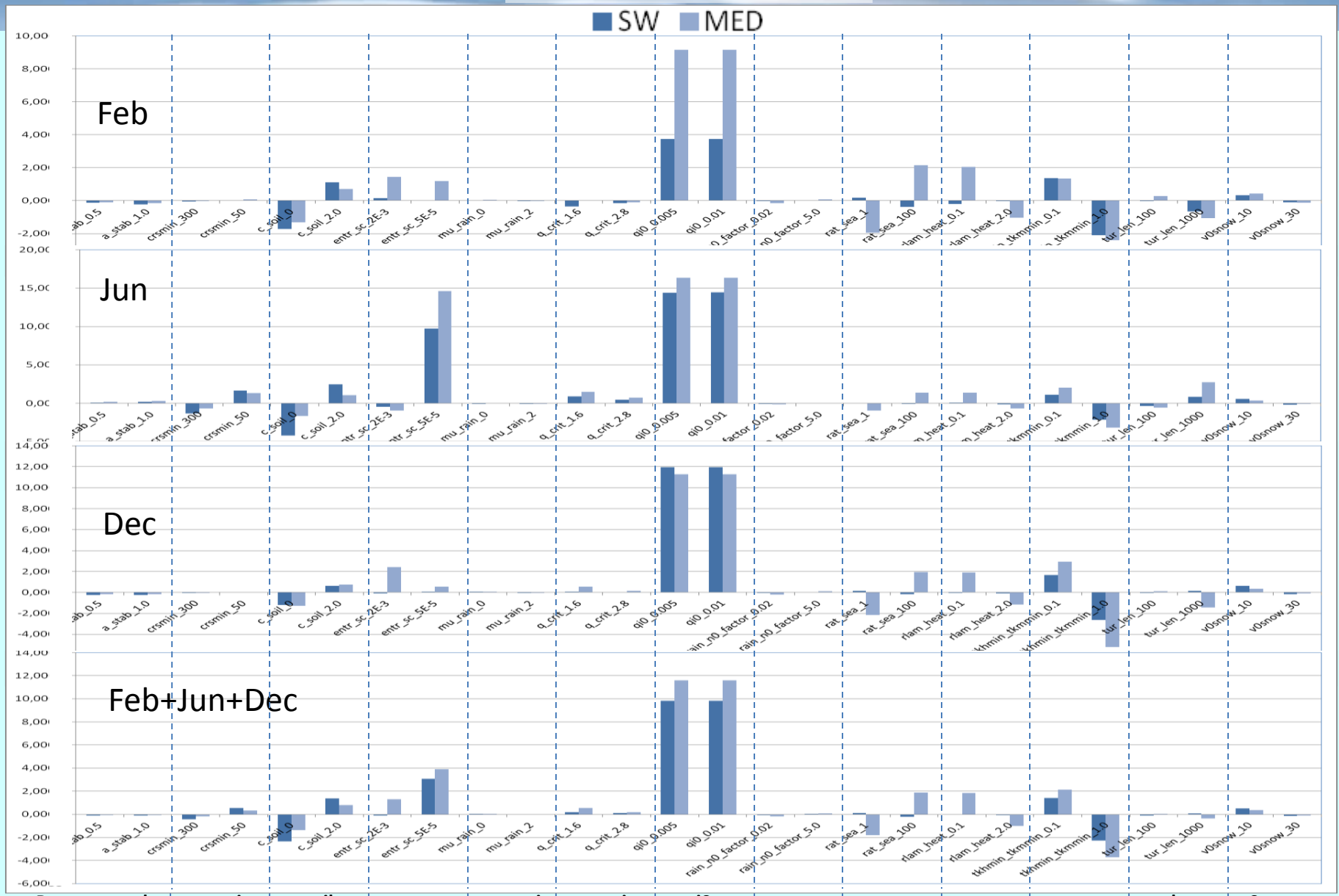
Sensitivity (%) for CLCT

$$S_{<CLCT>} = \frac{< CLCT >_{TEST} - < CLCT >_{DEFAULT}}{< CLCT >_{DEFAULT}} \bullet 100$$

Sensitivity (%) for CLCT

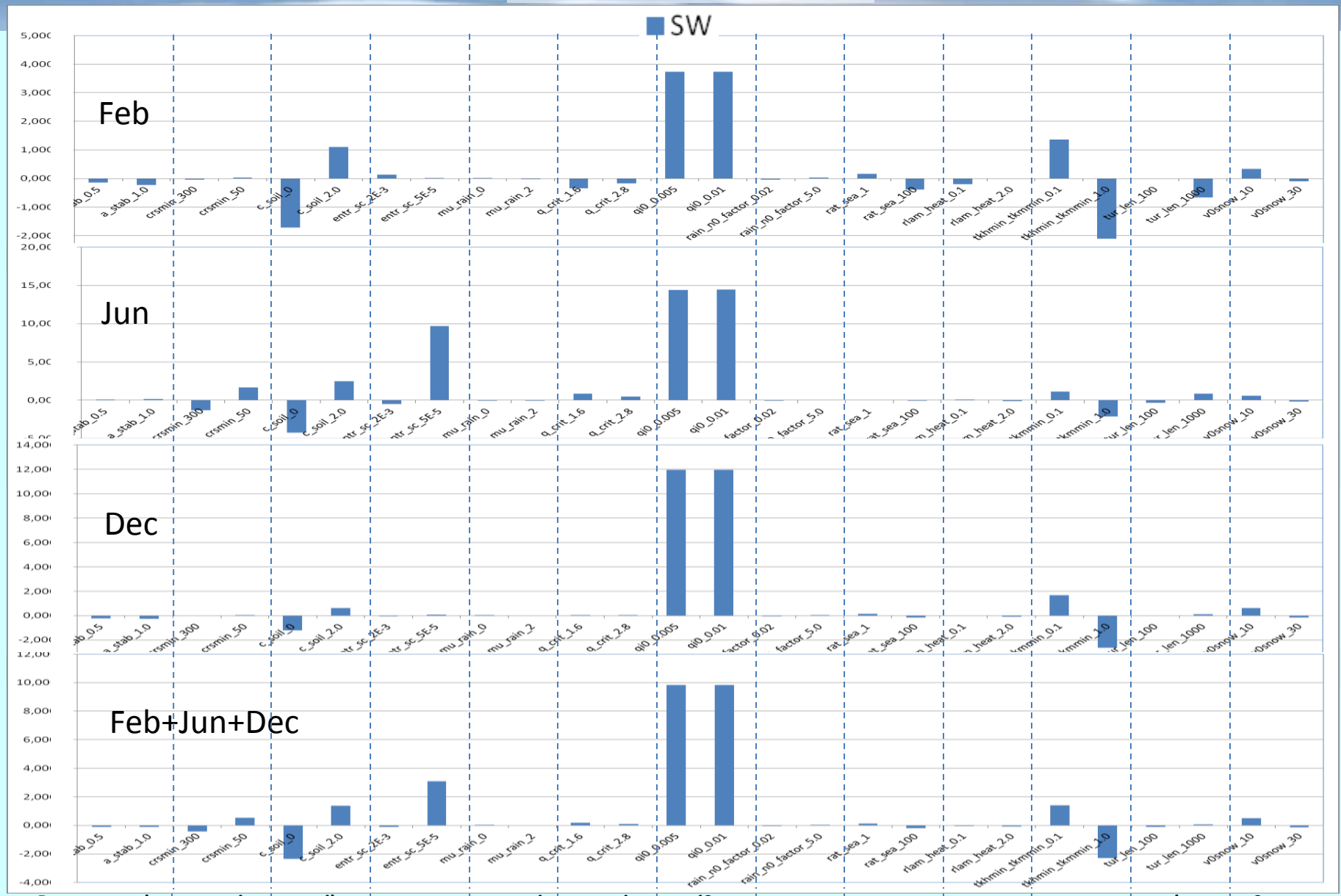
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCT



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCT



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

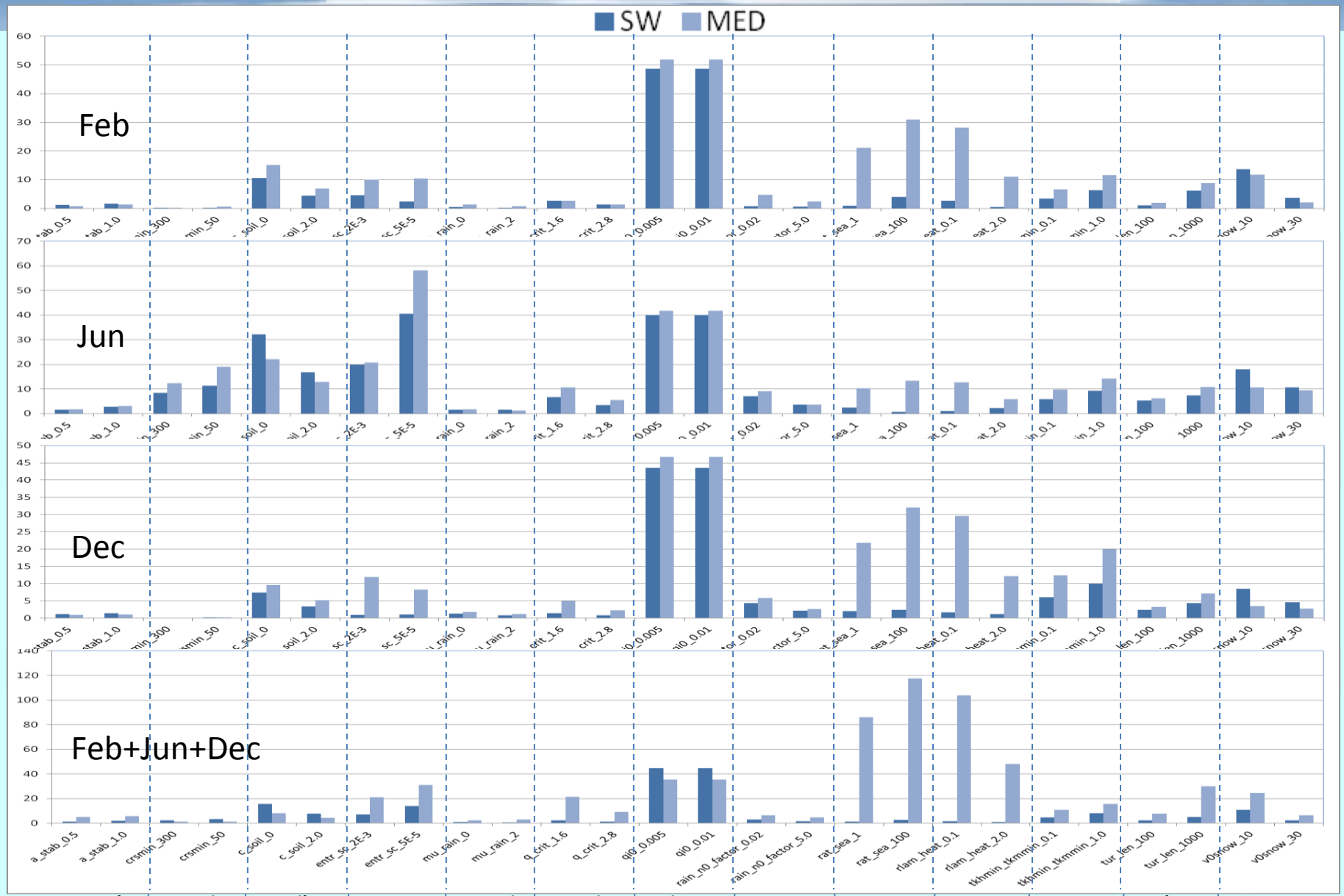
Sensitivity for {TOTPREC,SNOWGSP,CLCH,CLCM,CLCL}

$$S_{\{\langle \mathrm{TOTPREC} \rangle, \langle \mathrm{SNOWGSP} \rangle, \langle \mathrm{CLCH} \rangle, \langle \mathrm{CLCM} \rangle, \langle \mathrm{CLCL} \rangle\}} = \left|S_{\langle \mathrm{TOTPREC} \rangle}\right| + \left|S_{\langle \mathrm{SNOWGSP} \rangle}\right| + \left|S_{\langle \mathrm{CLCH} \rangle}\right| + \left|S_{\langle \mathrm{CLCM} \rangle}\right| + \left|S_{\langle \mathrm{CLCL} \rangle}\right|$$

Sensitivity for {TOTPREC,SNOWGSP,CLCH,CLCM,CLCL}

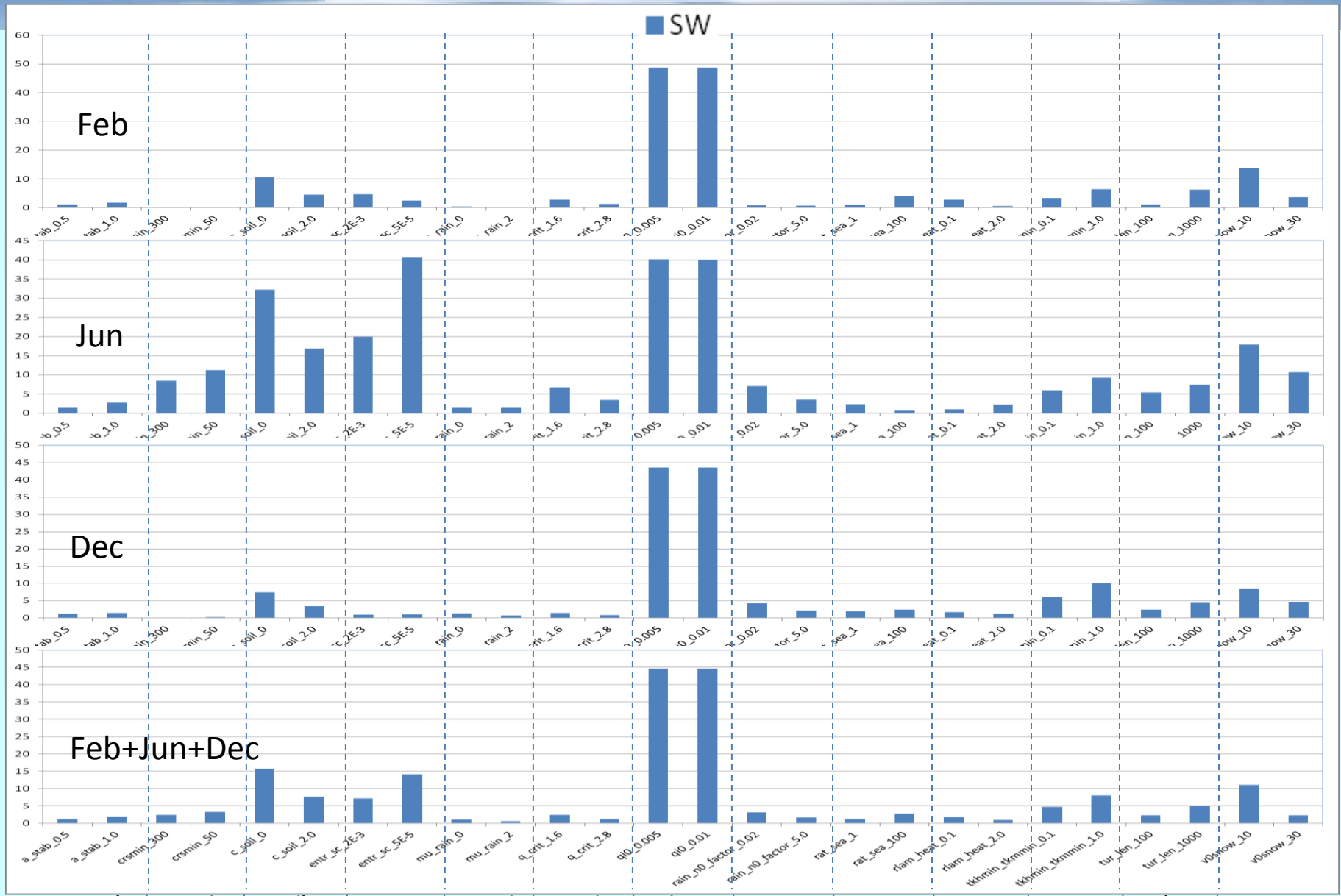
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for {TOTPREC,SNOWGSP,CLCH,CLCM,CLCL}



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity for {TOTPREC,SNOWGSP,CLCH,CLCM,CLCL}



Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

CONCLUSIONS:

- The impact for most of the parameters turned out to be important for all periods and domains.
- The weight of the parameter impact for the different domain varies due to their climatological characteristics as expected.
- In principle, for almost all considered variables, at most 5 parameters show the greatest sensitivity and a choice among them should be expected to provide a sufficient kernel for the application of the metamodel.
- Consequently, the use of the metamodel might be an option of very good operational value towards the opimization of COSMO model for domains of largely varied climatological characteristics.
- Uppon the success of the implementation of a metamodel, important information will be available to the experts that may be used in order to improve COSMO model and Numerical Weather Prediction in general.