On the Domain Sensitivity of COSMO Model over the Mediterranean Area

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Motivation

- Based on the framework of previous works, the COSMO model *sensitivity* of selected domains is investigated in reference to this of the wider domain of the Mediterranean area.

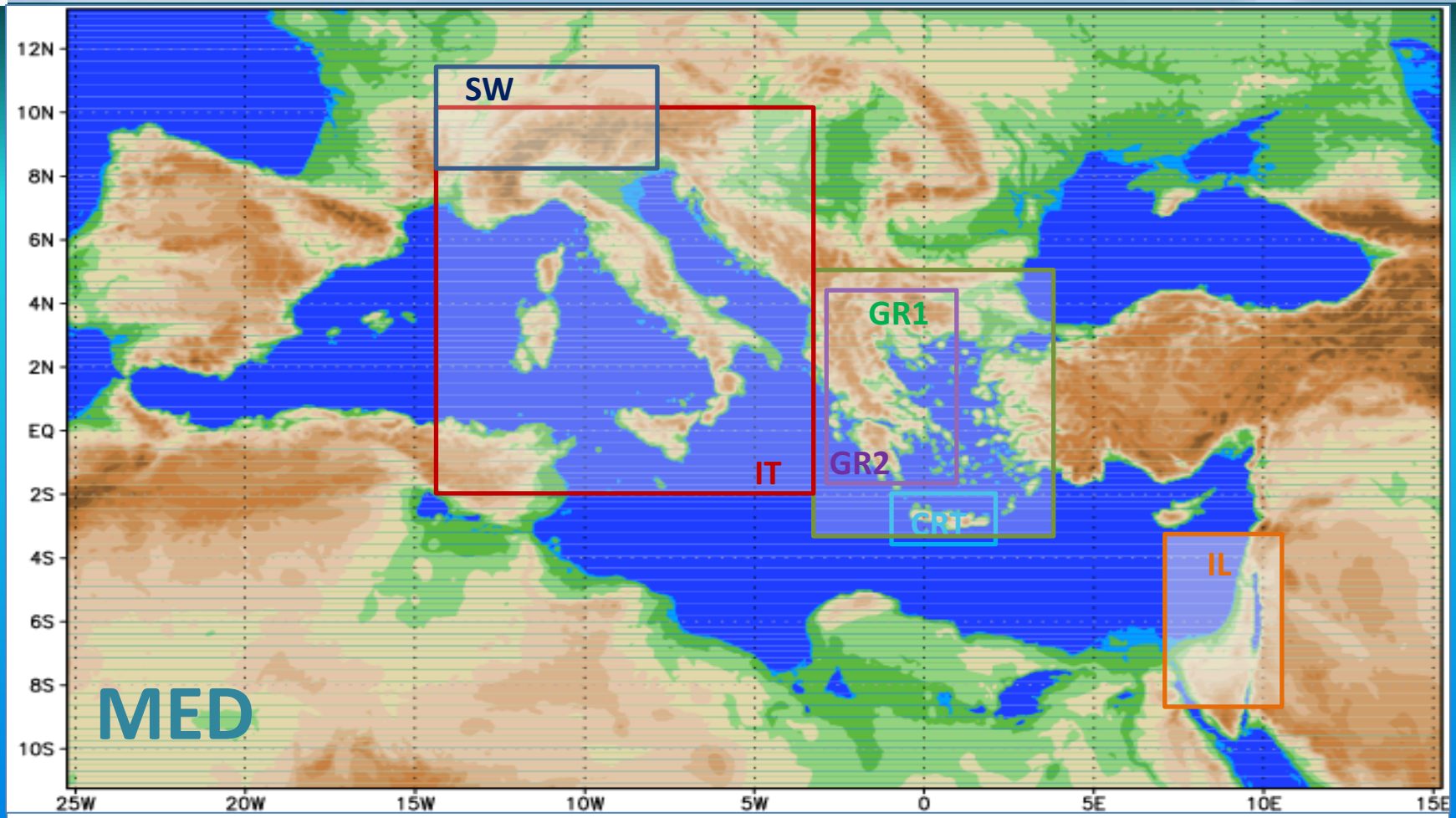
  http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport32.pdf
  http://www.cosmo-model.org/content/consortium/generalMeetings/general2016/wg3b/CALMO_Avgoustoglou.pdf
  http://www.cosmo-model.org/content/consortium/generalMeetings/general2015/parallel/WG3b_Euripides_Sept2015.pdf

- Based on the resulting similarities trace *heuristically* any model parameters for testing, especially for the domain of Greece.

Outline

- Model set up.
- Parameter set up
- Test description
- Domain Sensitivities (Decision process)
- Comparisons with observations for the domain of Greece
- Conclusions

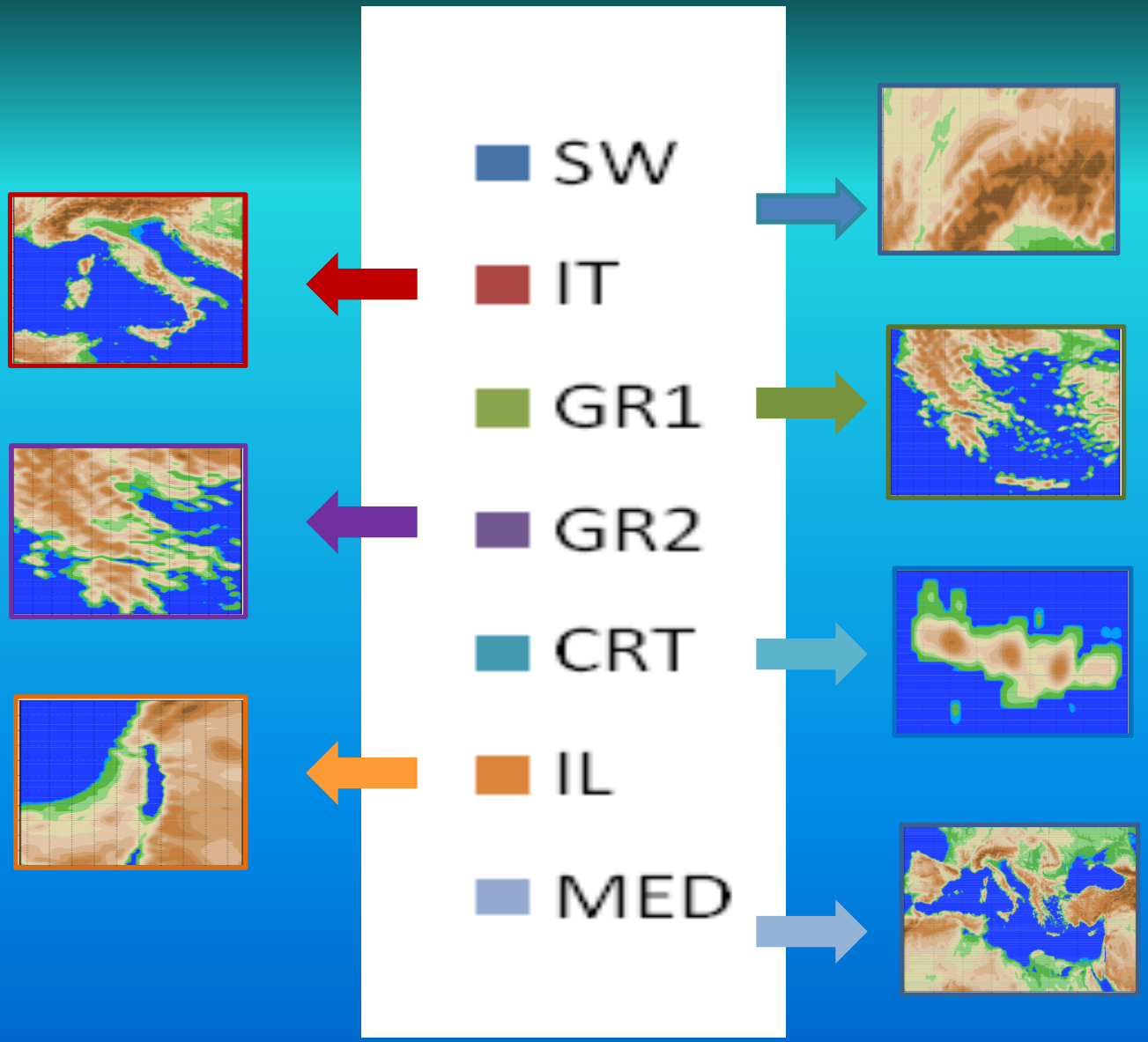
SELECTED DOMAINS (1)



Selection 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.

- Marine vs Continental areas (GR1 vs. SW or GR2 vs CRT(!))
- Significant longitudinal difference (GR vs IL)

SELECTED DOMAINS (2)



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).

SENSITIVITY TESTS BLUEPRINT

13 parameters were considerd.

⊗

All combinations between default, min and max parameter values + some intermediate parameter values

⊗

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

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~5000 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 ~ 20 million b.u. on Cray X C30 of ECMWF (gratis HNMS).

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)

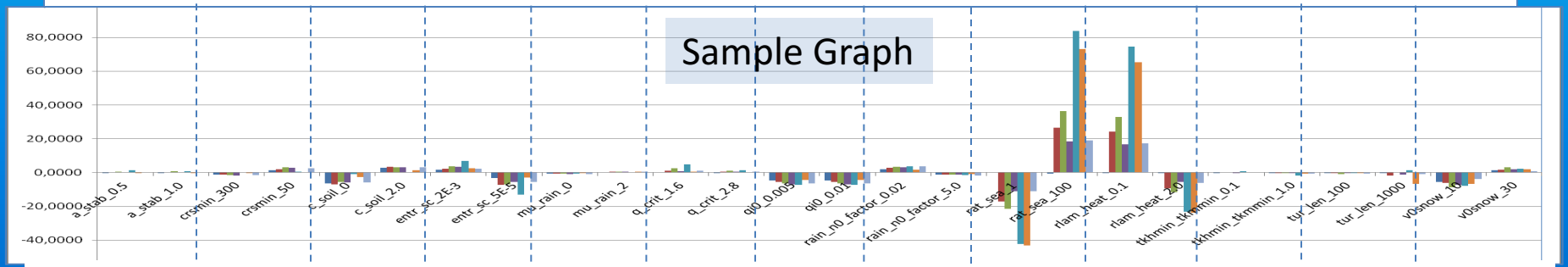
$$S_{<P>}(\%) = \frac{< P >_{TEST} - < P >_{DEFAULT}}{< P >_{DEFAULT}} \bullet 100$$

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

$$S_{\begin{bmatrix} TMIN2m \\ TMAX2m \end{bmatrix}} = \begin{bmatrix} < TMIN2m > \\ < TMAX2m > \end{bmatrix}_{TEST} - \begin{bmatrix} < TMIN2m > \\ < TMAX2m > \end{bmatrix}_{DEFAULT}$$

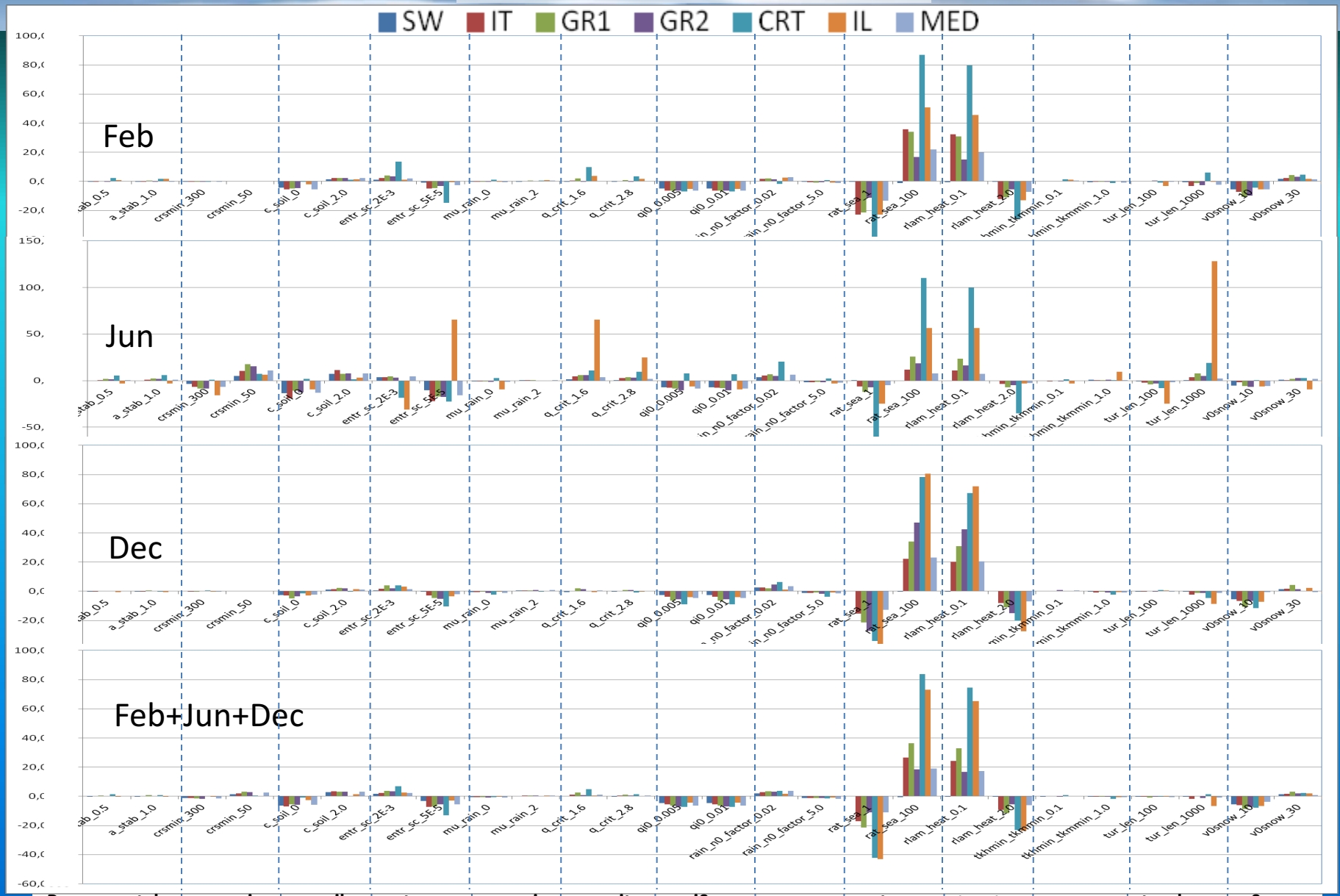
GRAPH FEATURES

- 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 ●

Sensitivity (%) for TOTPREC (1)



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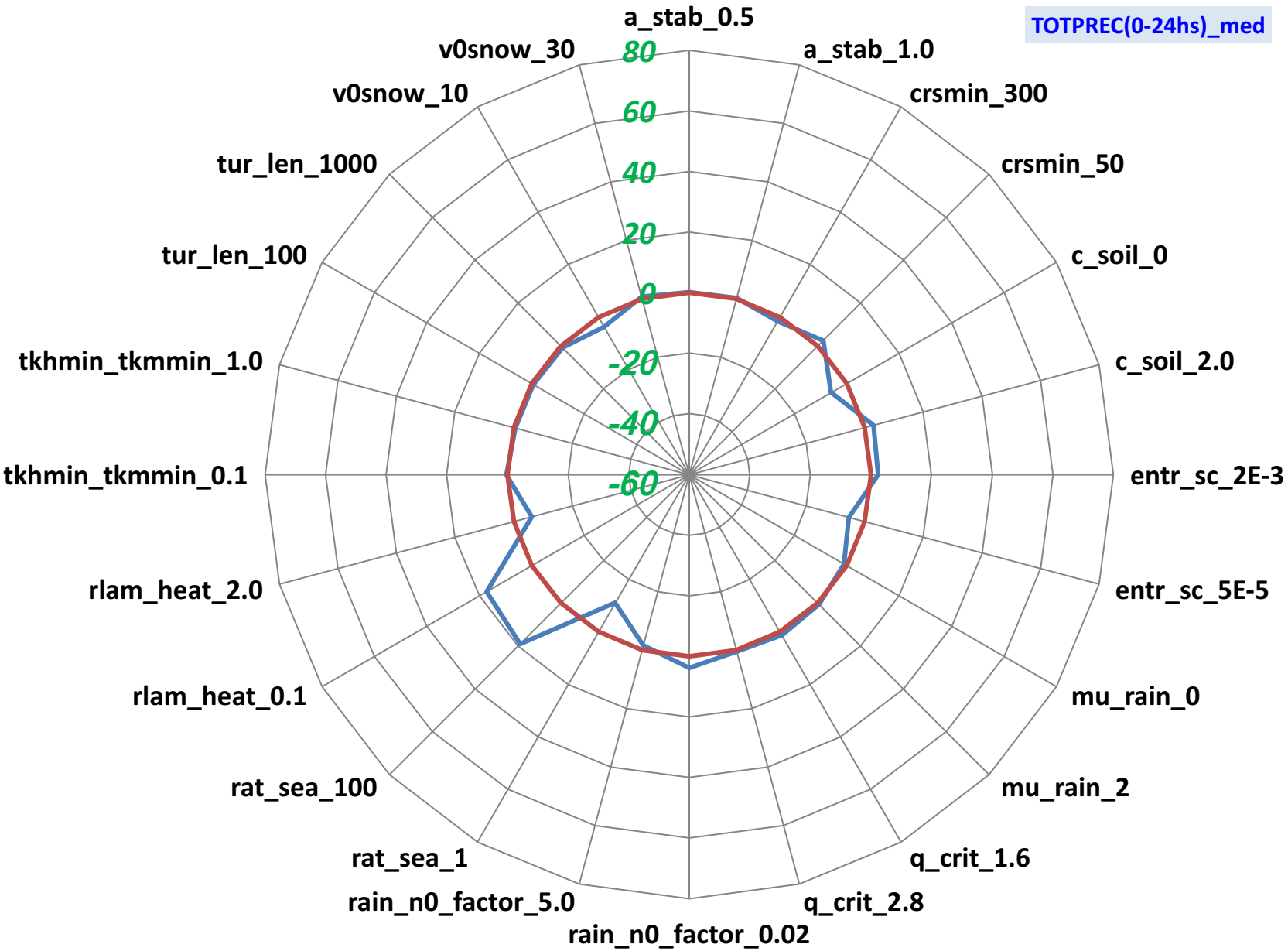
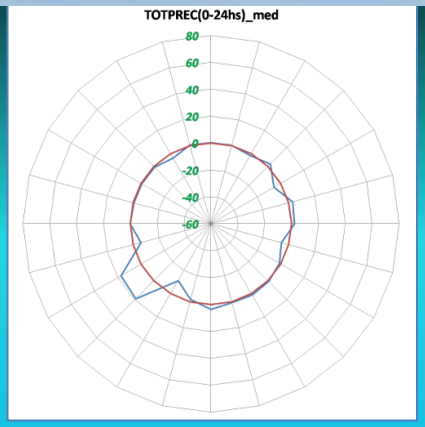
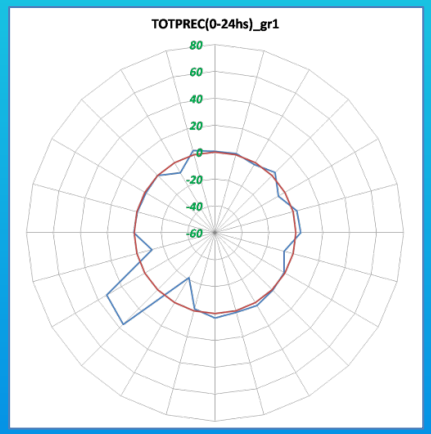
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

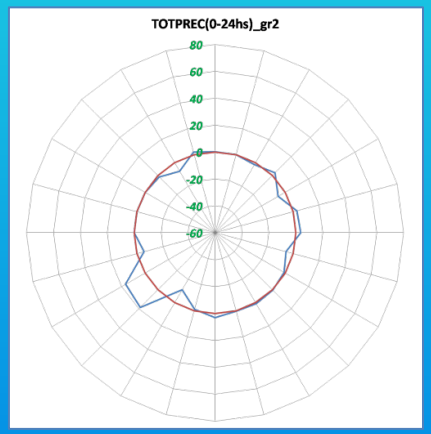
Sensitivity (%) for TOTPREC (2)

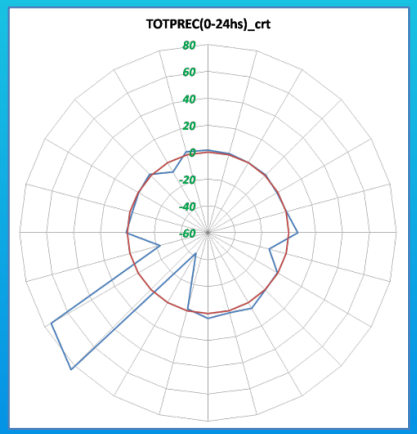


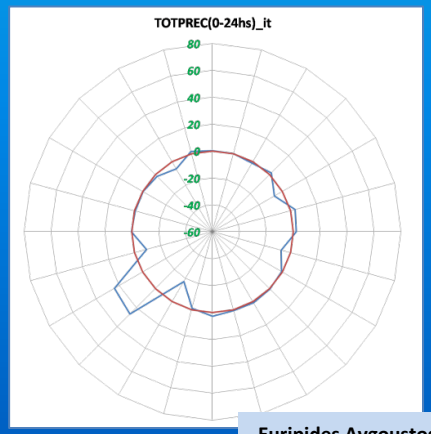
Sensitivity (%) for TOTPREC (3)

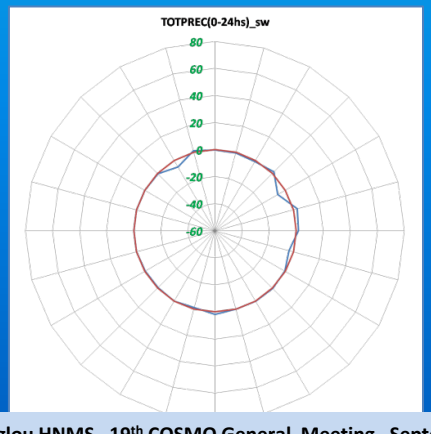


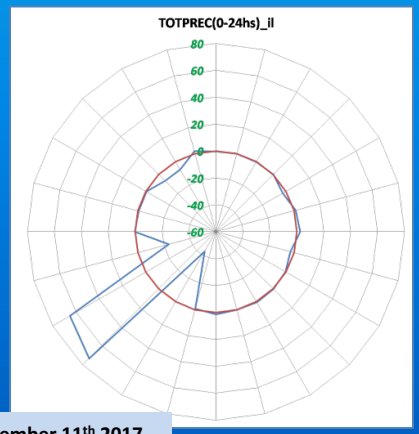




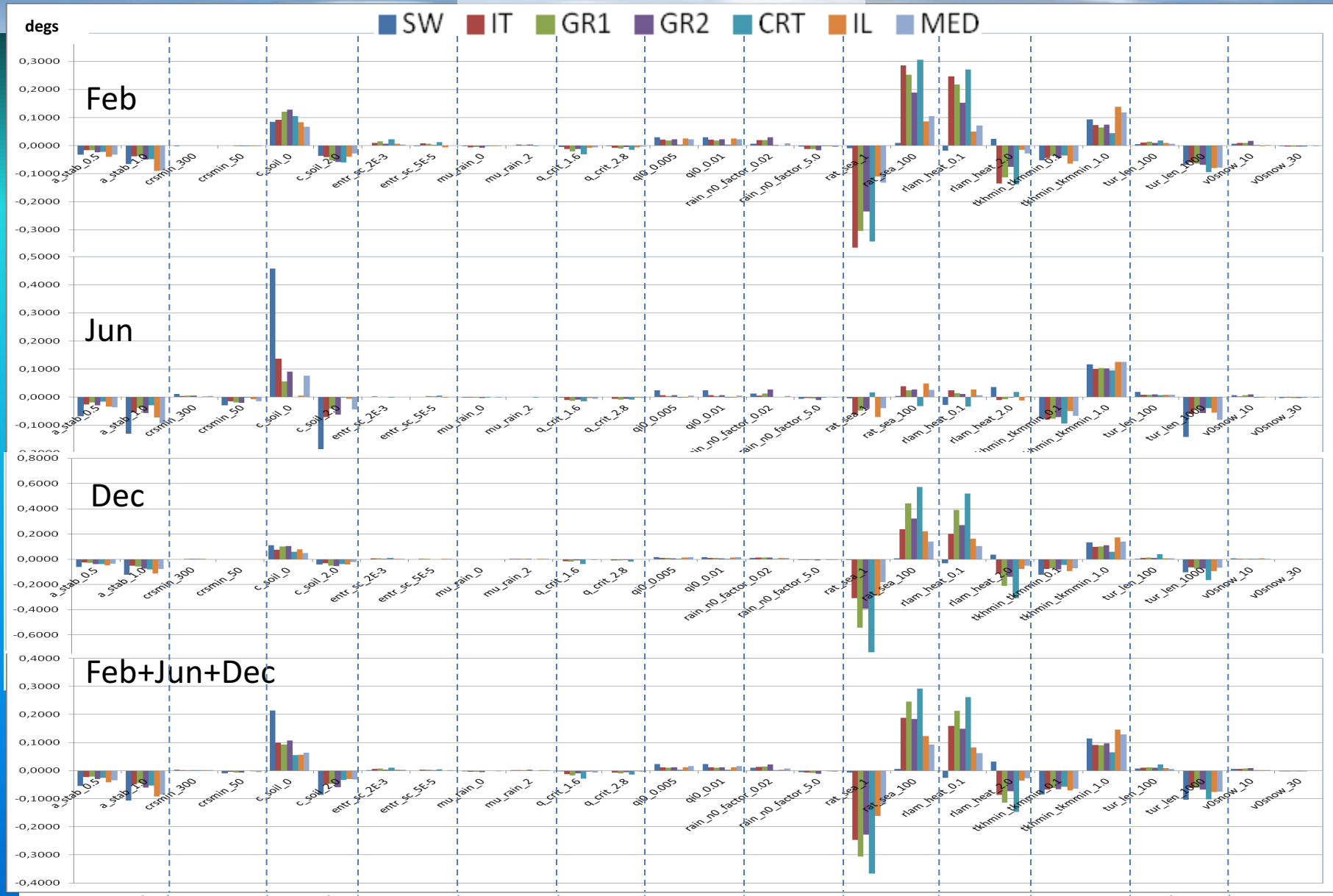








Sensitivity for TMIN2m (1)



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
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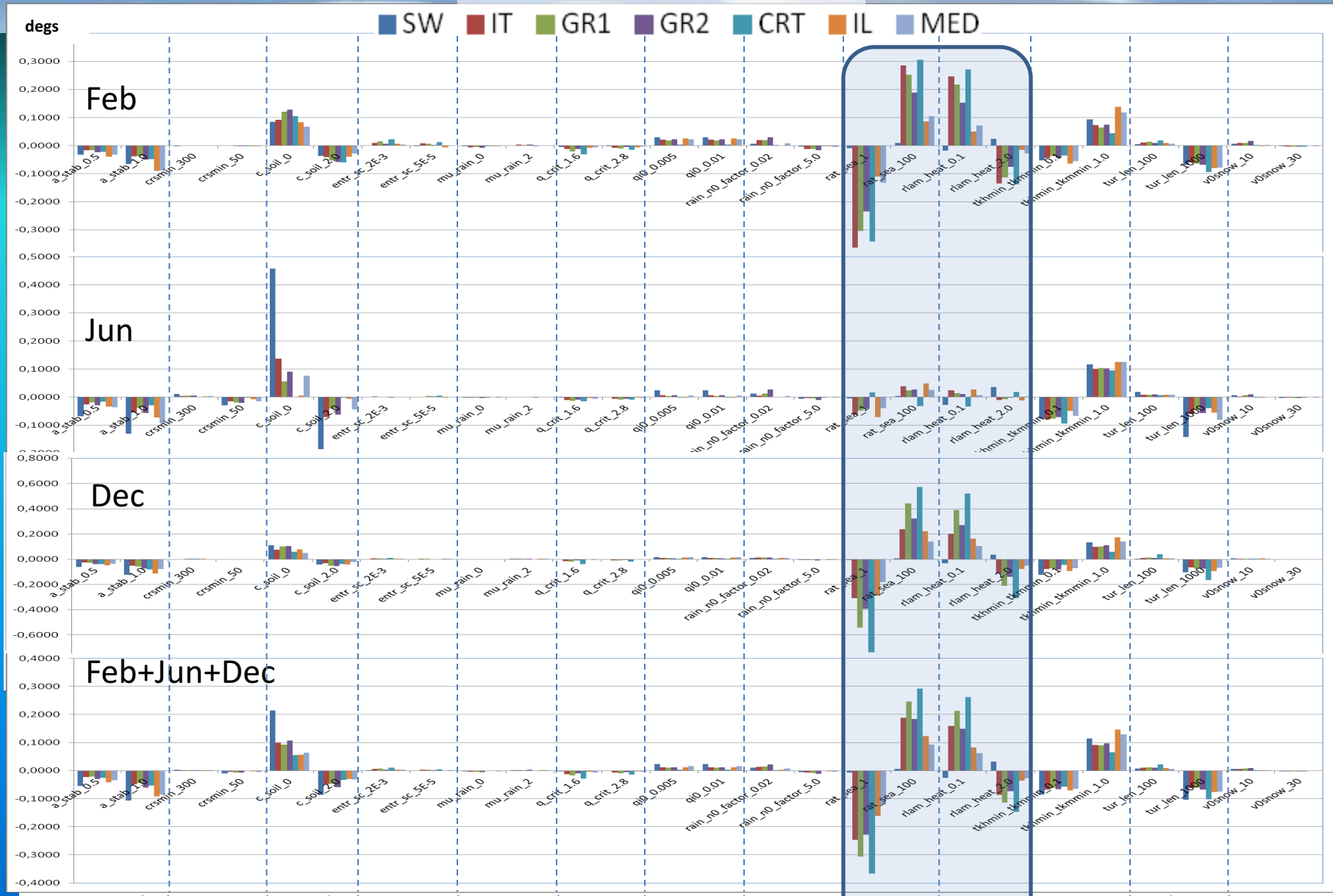

Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
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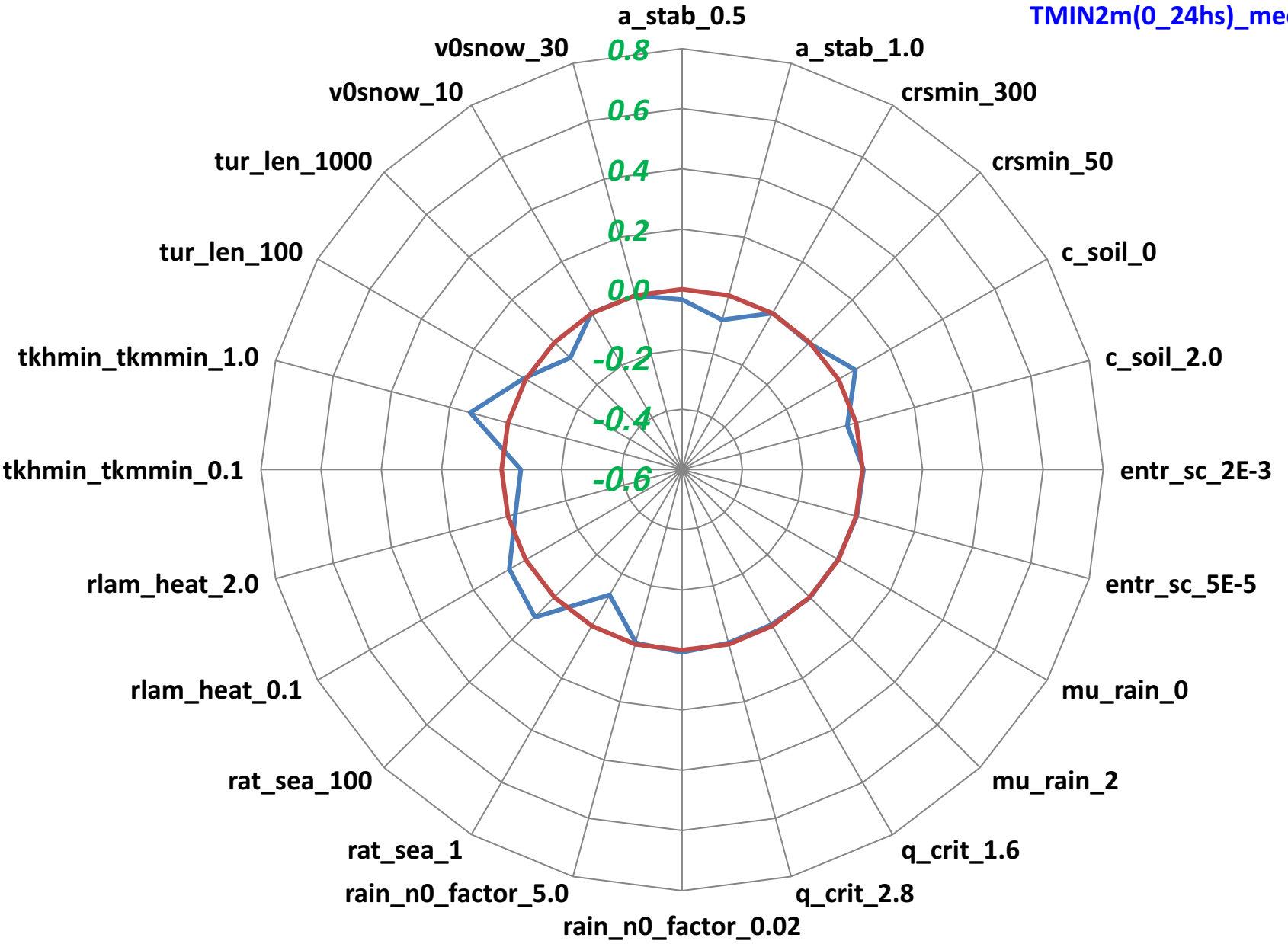
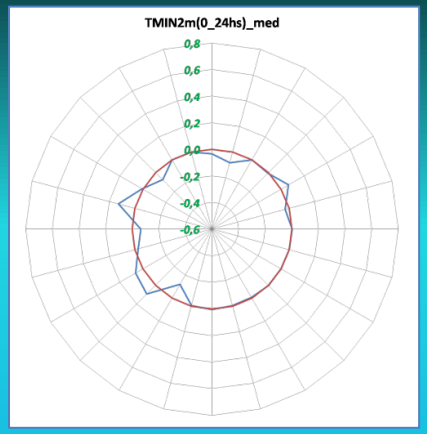
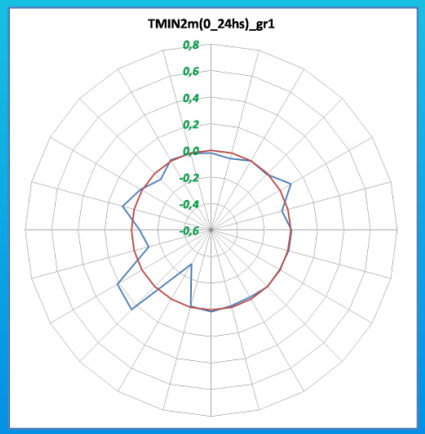
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

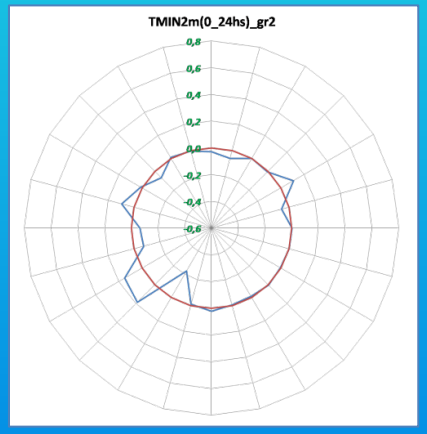
Sensitivity for TMIN2m (2)

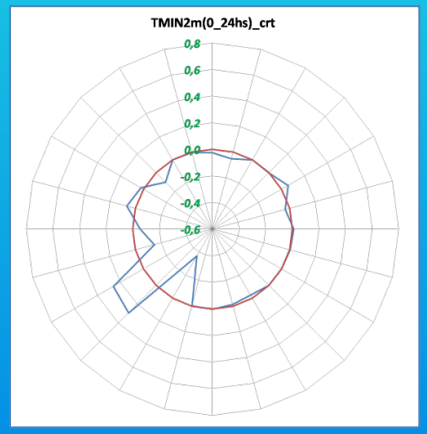


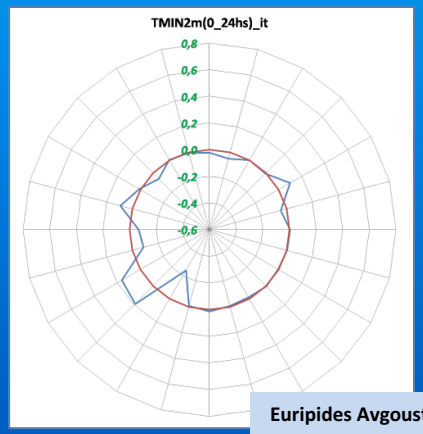
Sensitivity for TMIN2m (3)

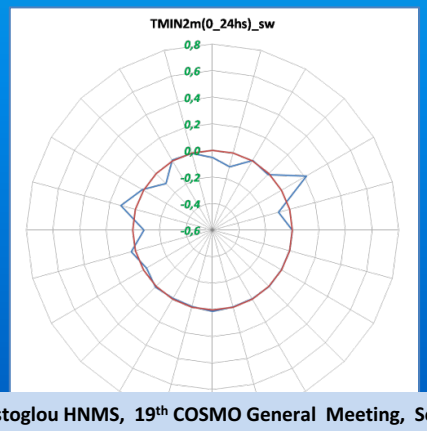


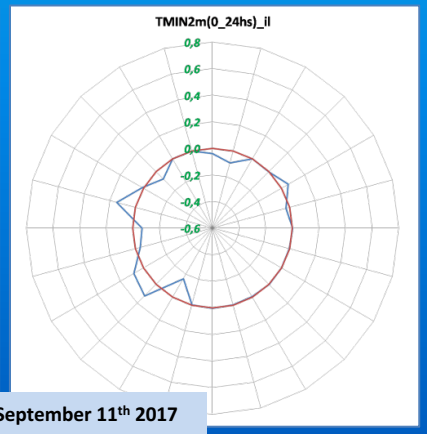




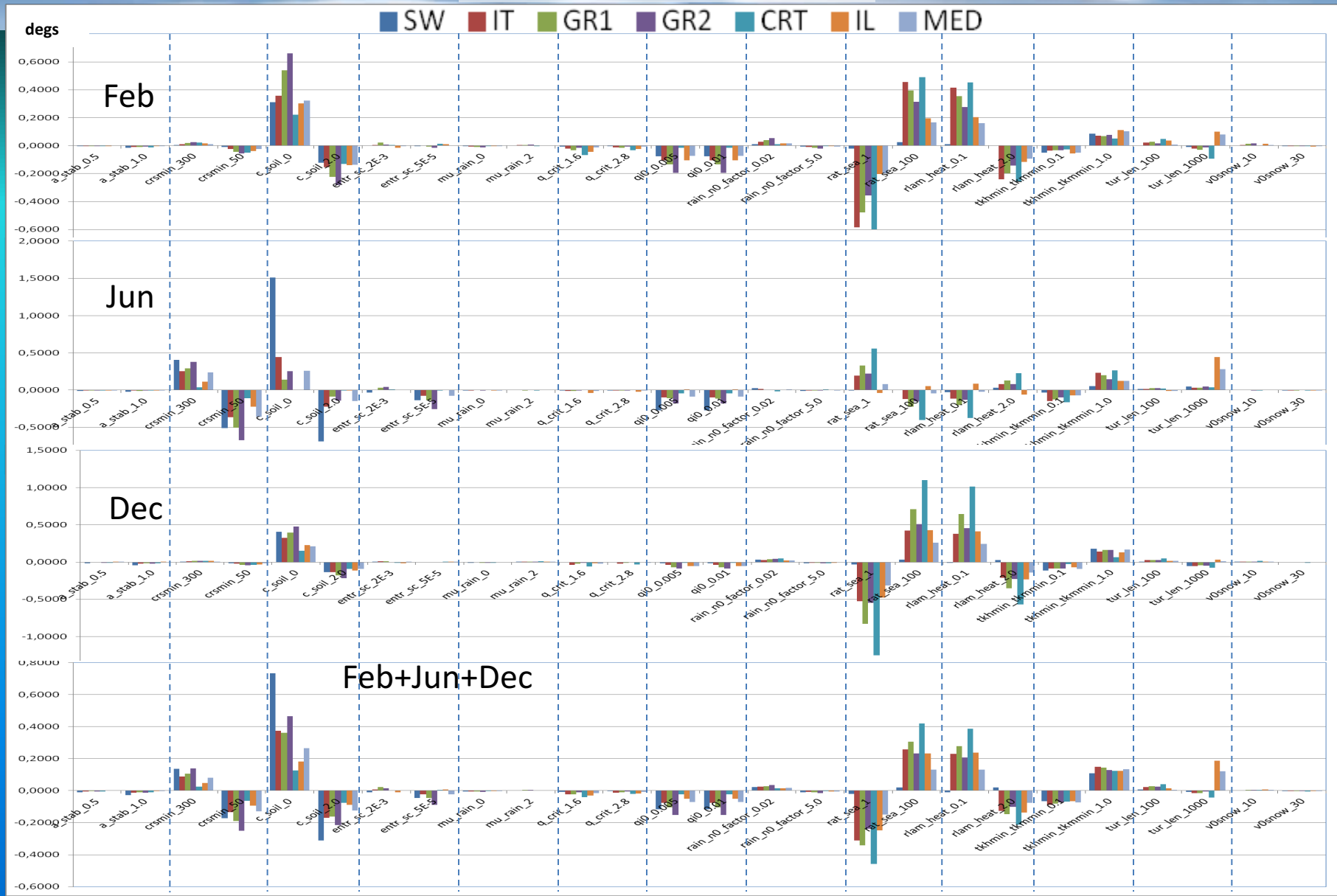








Sensitivity for TMAX2m (1)



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

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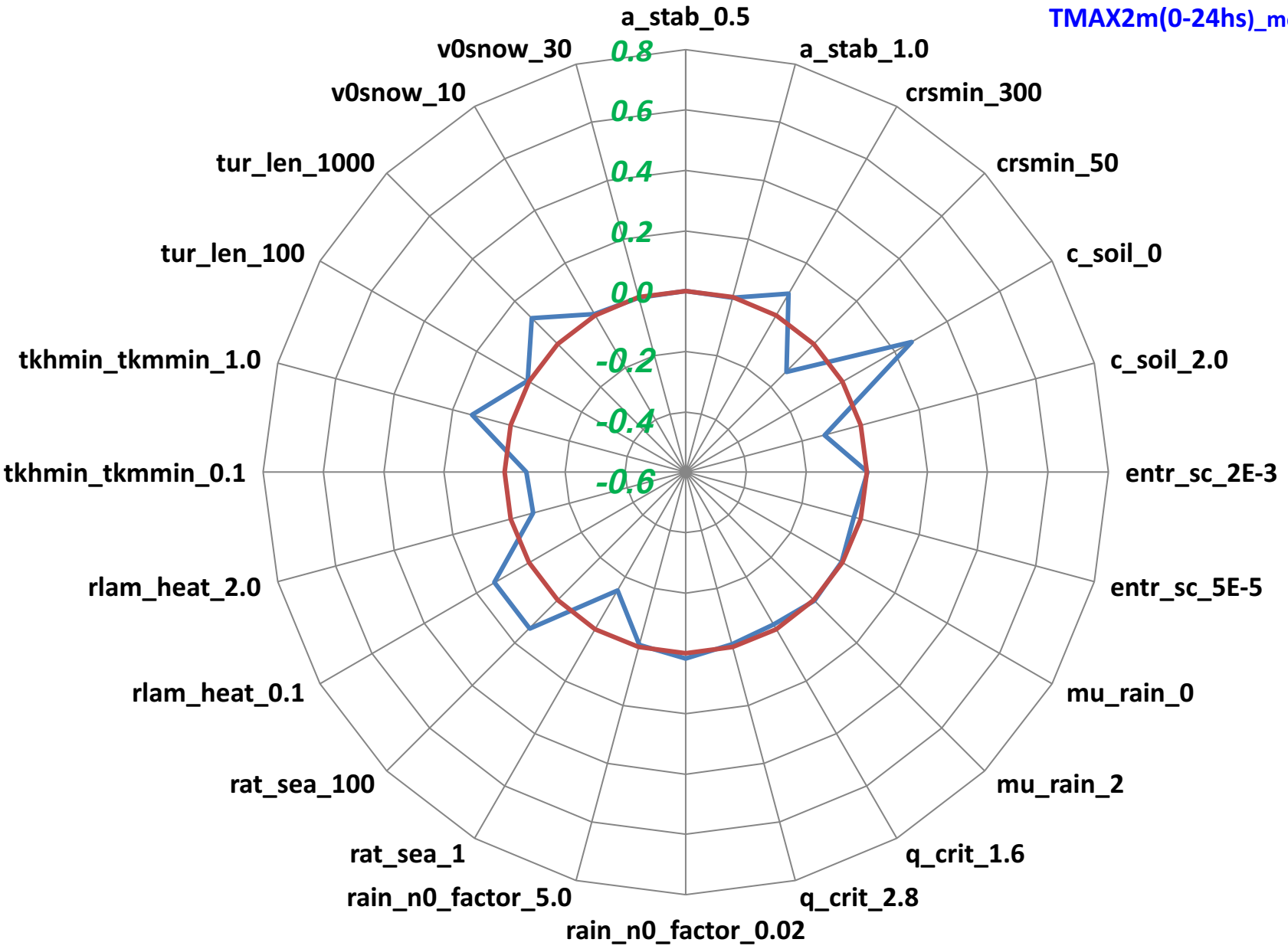
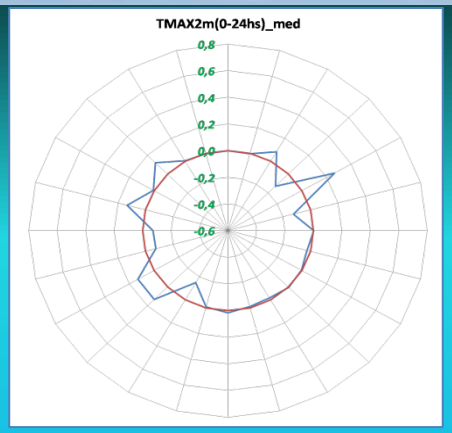
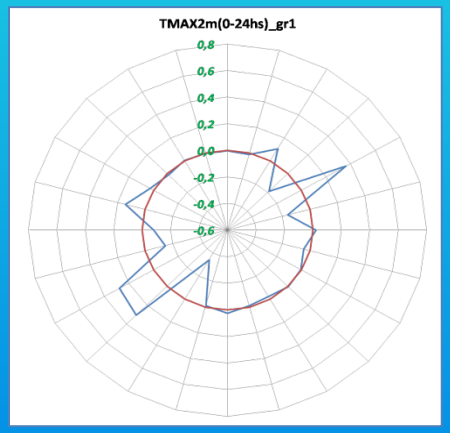
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

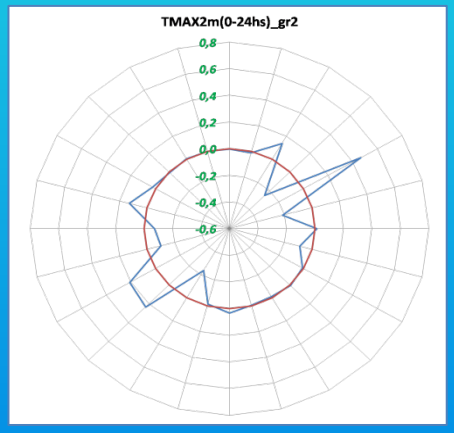
Sensitivity for TMAX2m (2)

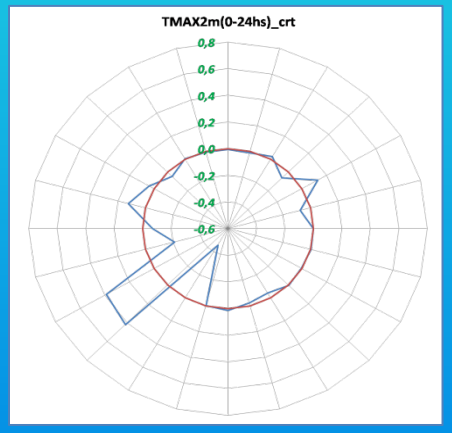


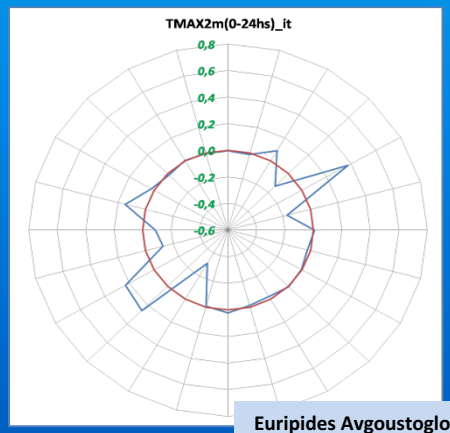
Sensitivity for TMAX2m (3)

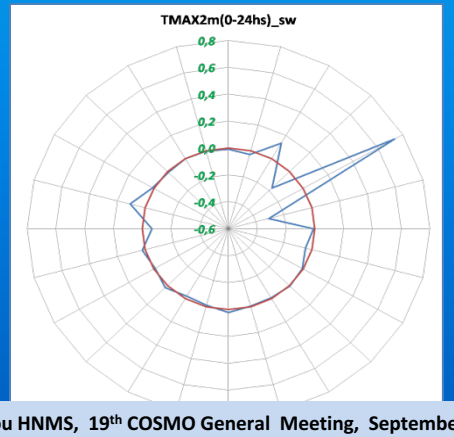


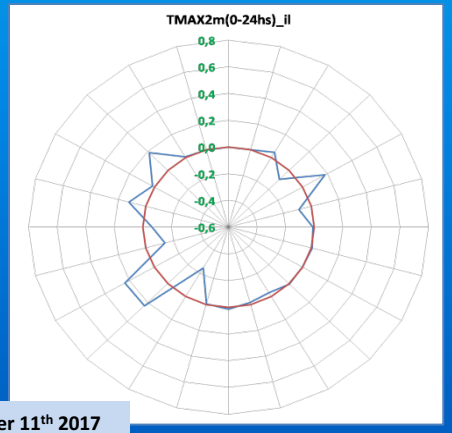












Sensitivity (%) for CLCL (1)

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
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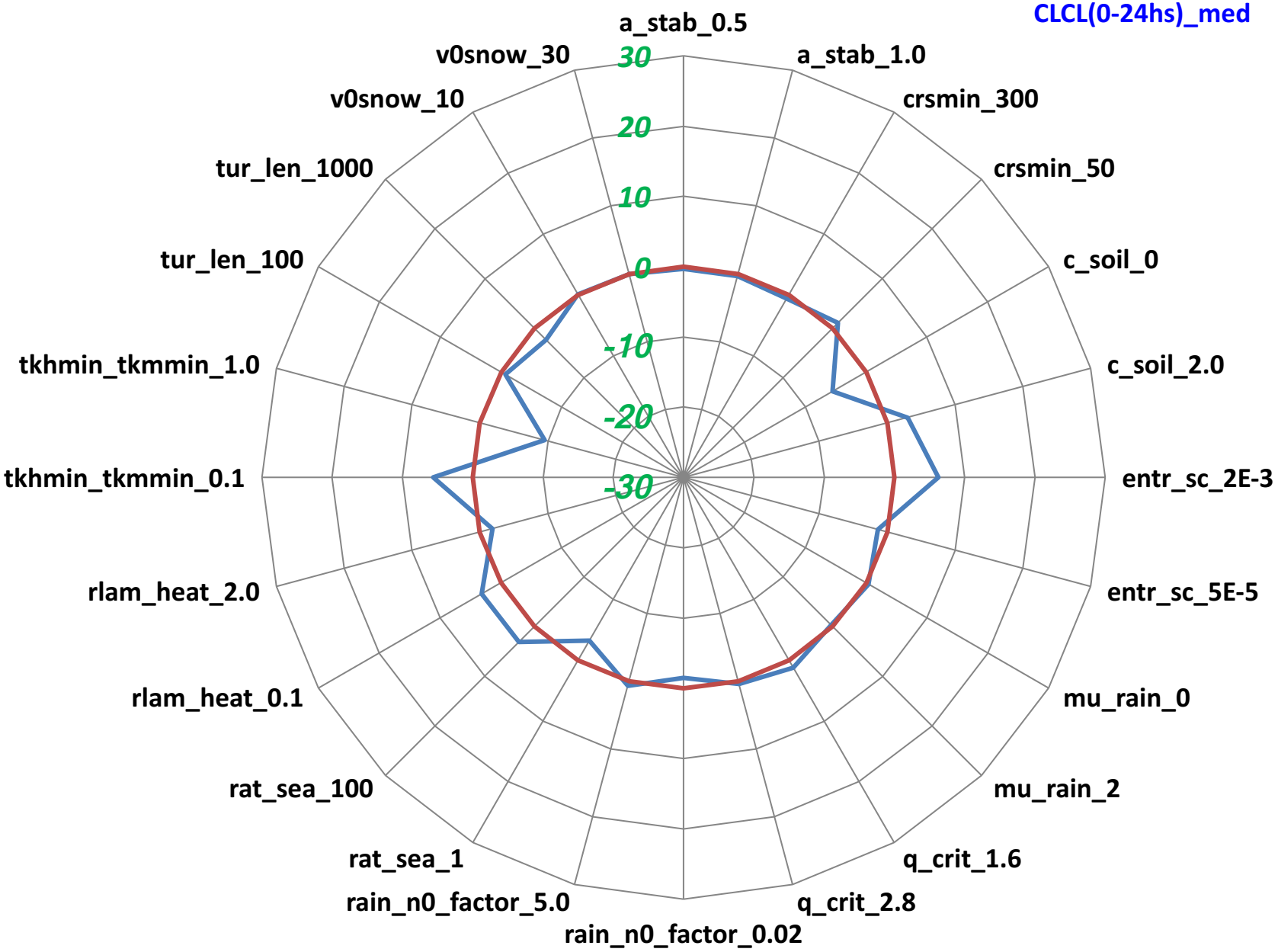
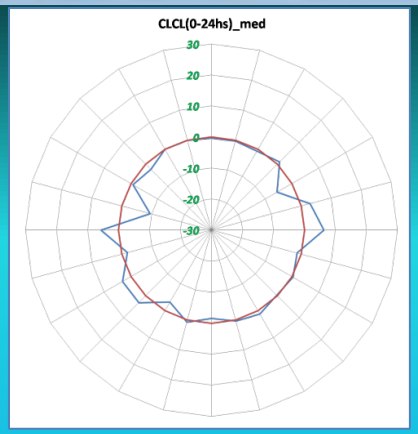
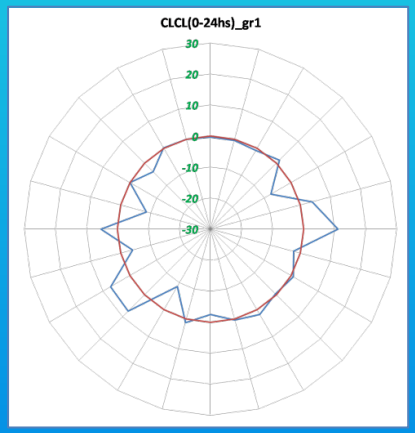
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

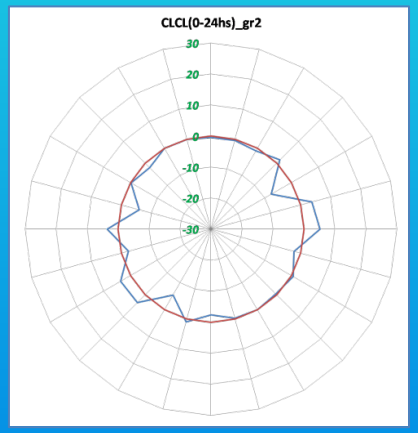
Sensitivity (%) for CLCL (2)

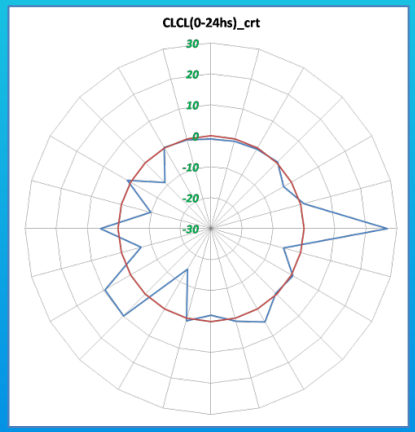


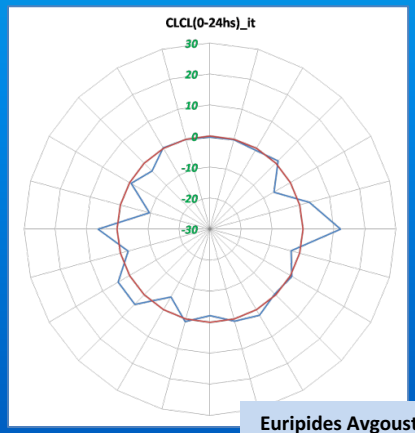
Sensitivity (%) for CLCL (3)

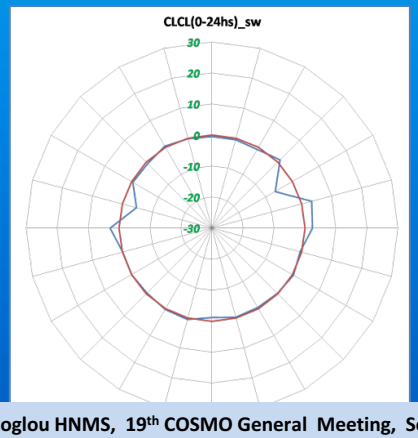


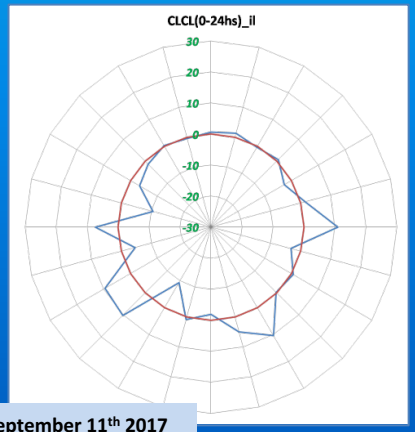




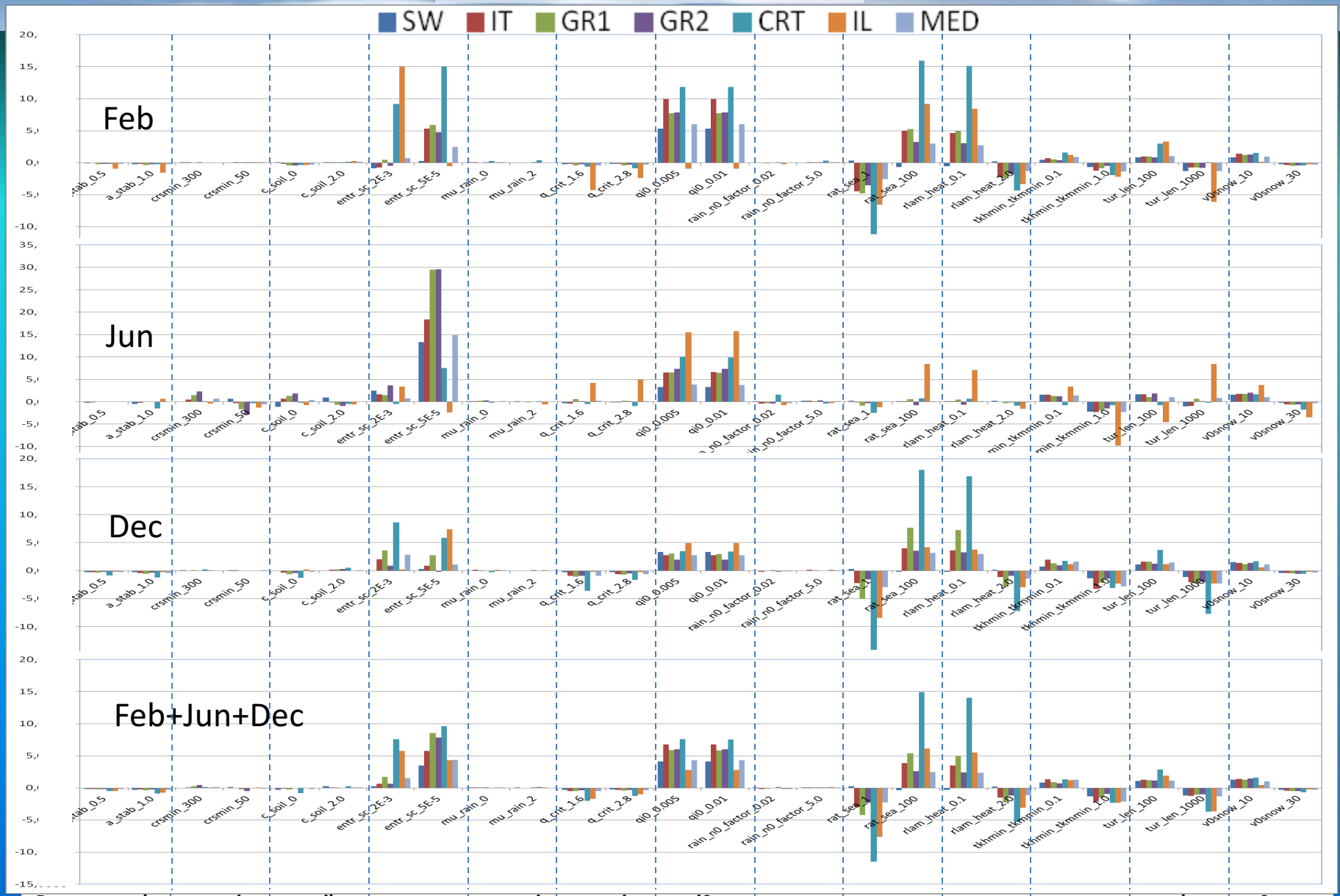






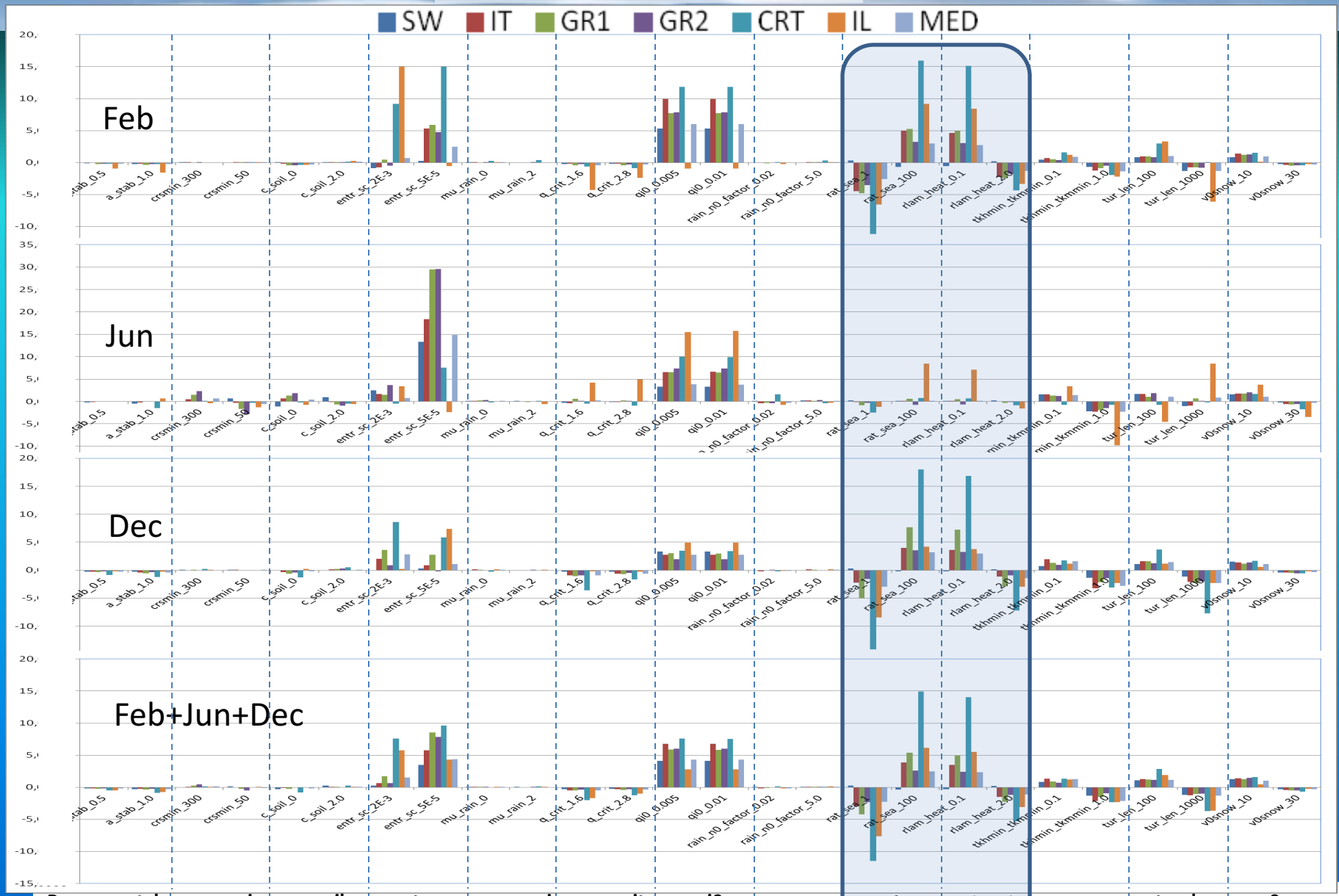


Sensitivity (%) for CLCM (1)



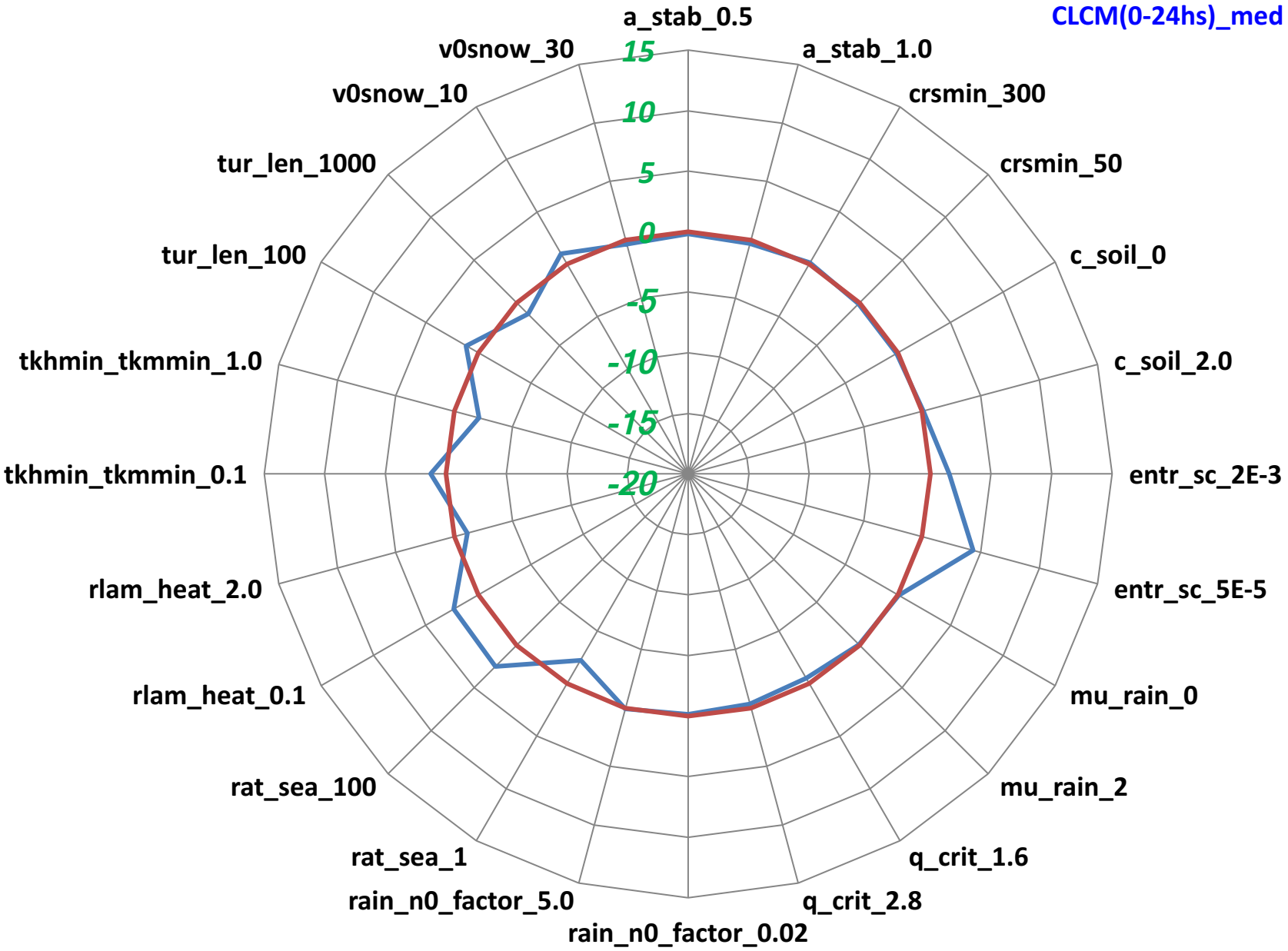
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

Sensitivity (%) for CLCM (1)

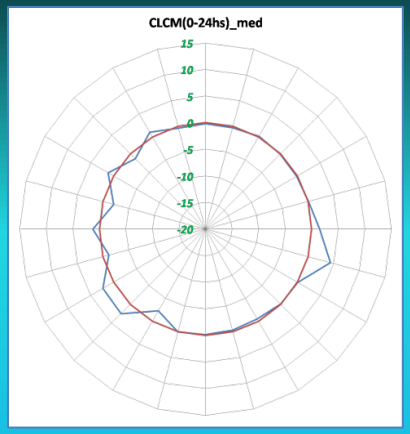


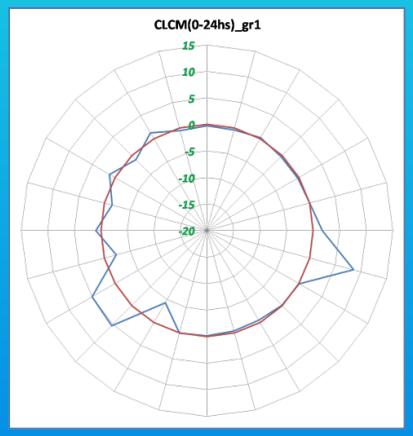
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

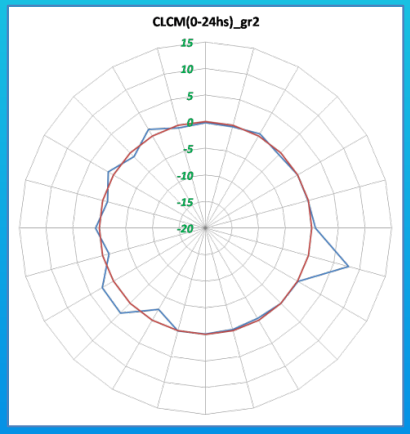
Sensitivity (%) for CLCM (2)

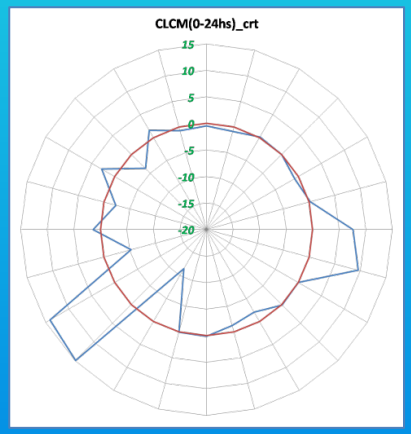


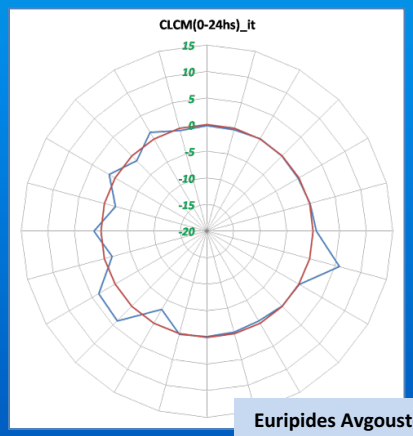
Sensitivity (%) for CLCM (3)

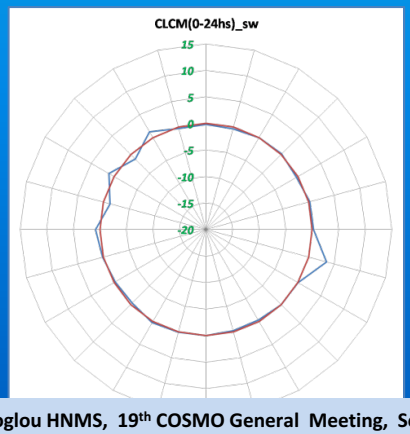


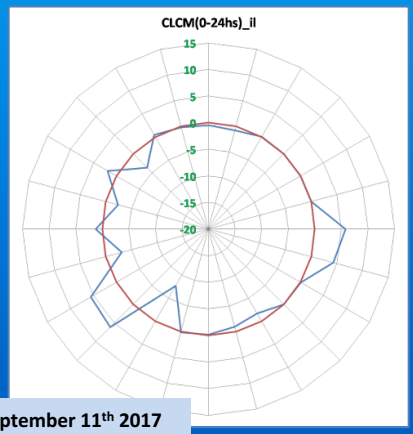












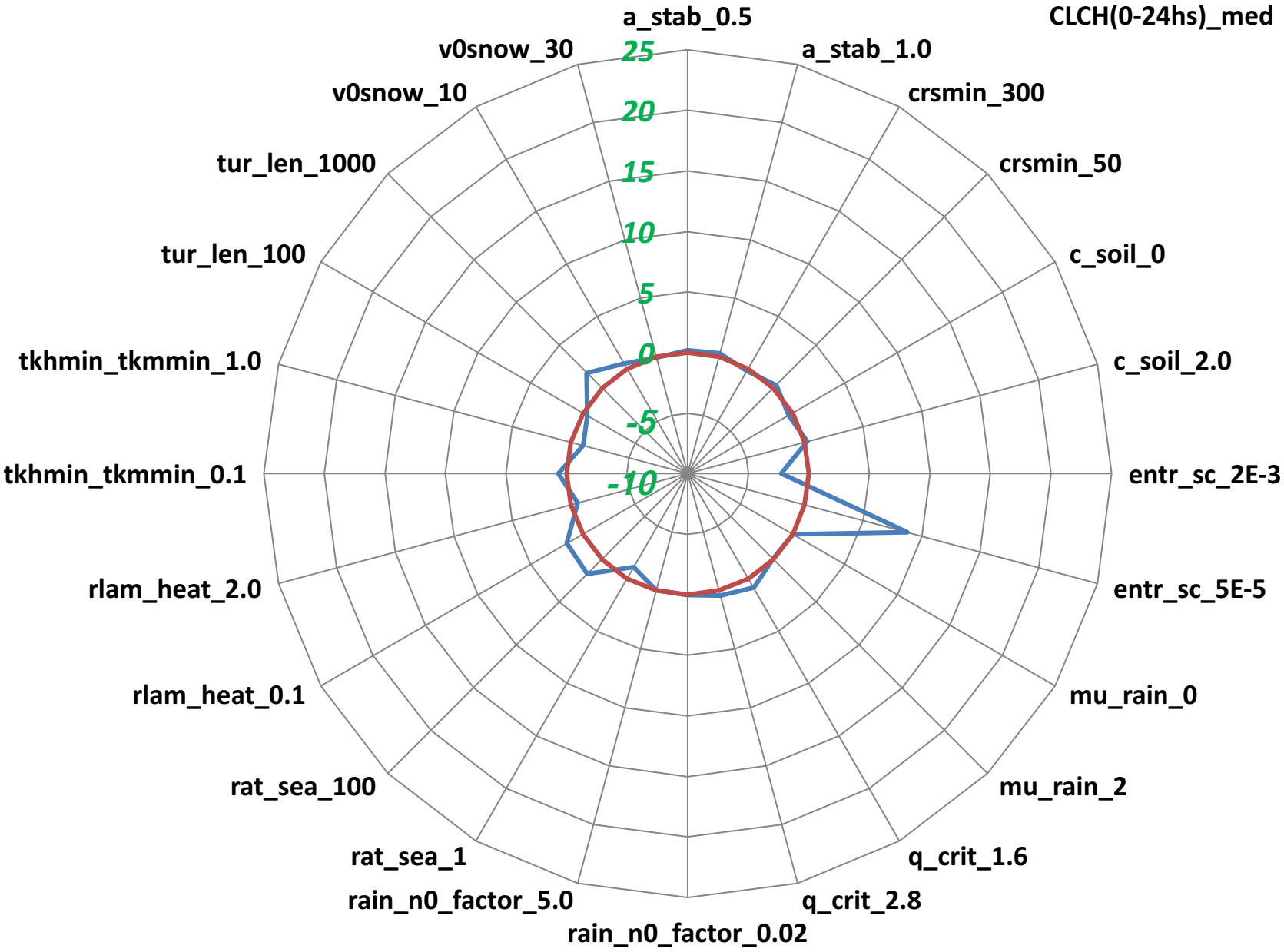
Sensitivity (%) for CLCH (1)

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

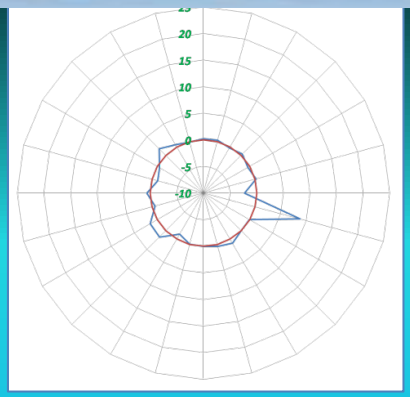
Sensitivity (%) for CLCH (1)

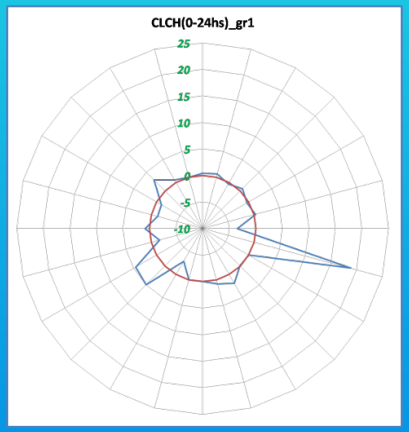
Pars:	a_stab	crsmin	c_soil	entr_sc	mu_rain	q_crit	qi0	rain_n0_factor	rat_sea	rlam_heat	tkhmin_tkmmin	tur_len	v0snow
Lims:	0.0, 1.0	50, 300	0, 2	5E-5, 2E-3	0, 2	1.6, 2.8	0, 0.01	0.02, 5.0	10, 100	0.1, 2.0	0.1, 1.0	100, 1000	10, 30
Def :	0.5	150	1	3E-4	1	4.0	0.005	1.0	20	1.0	0.4	150	20

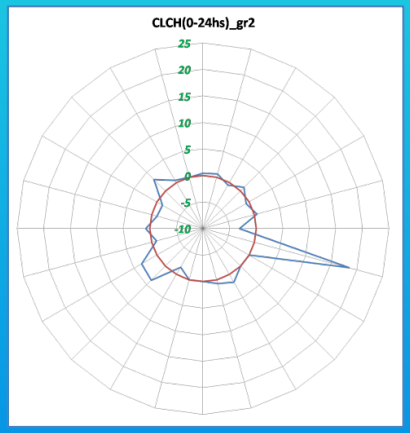
Sensitivity (%) for CLCH (2)

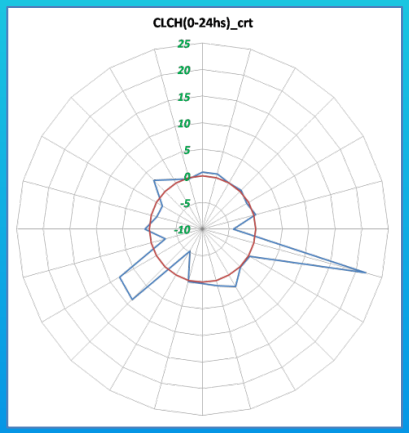


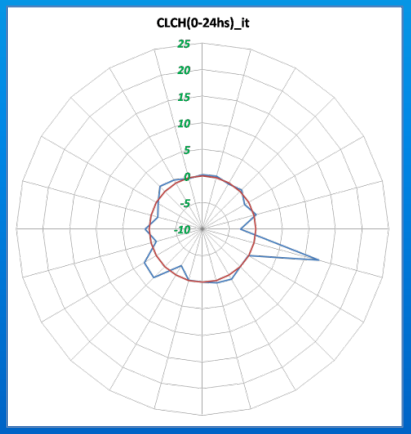
Sensitivity (%) for CLCH (3)

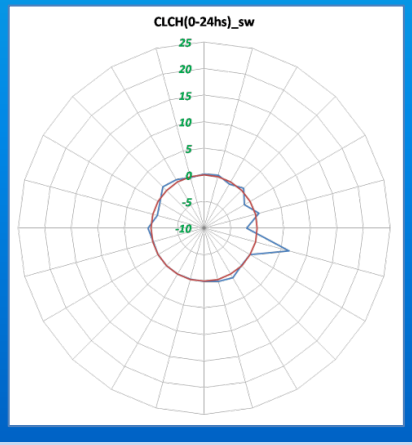


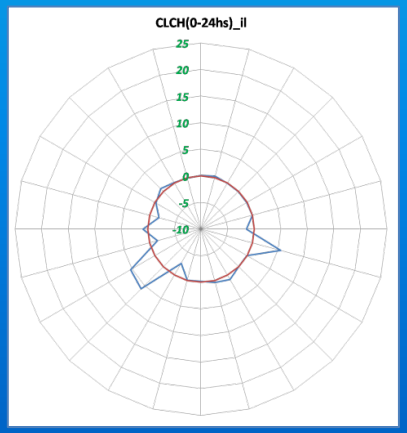




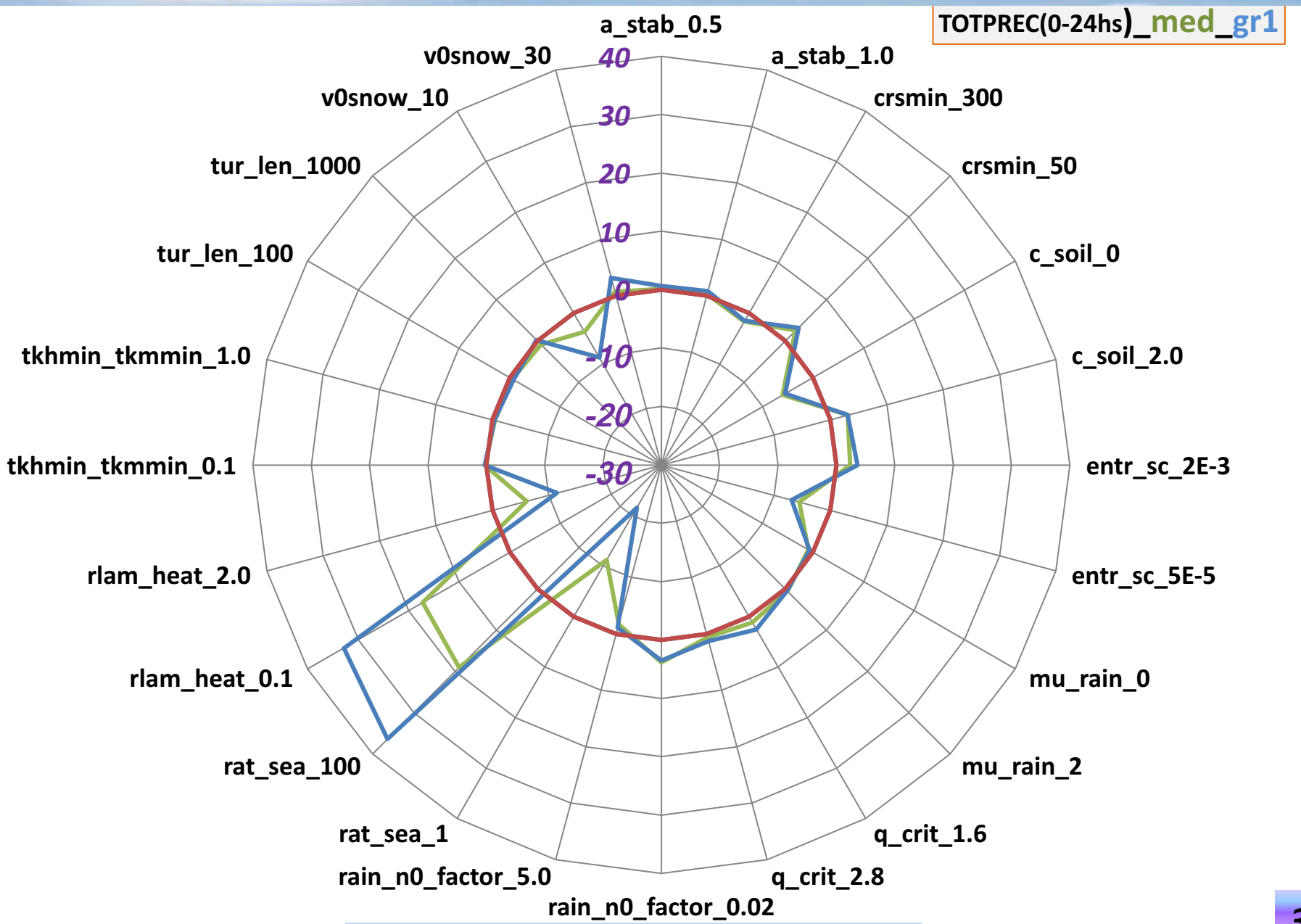




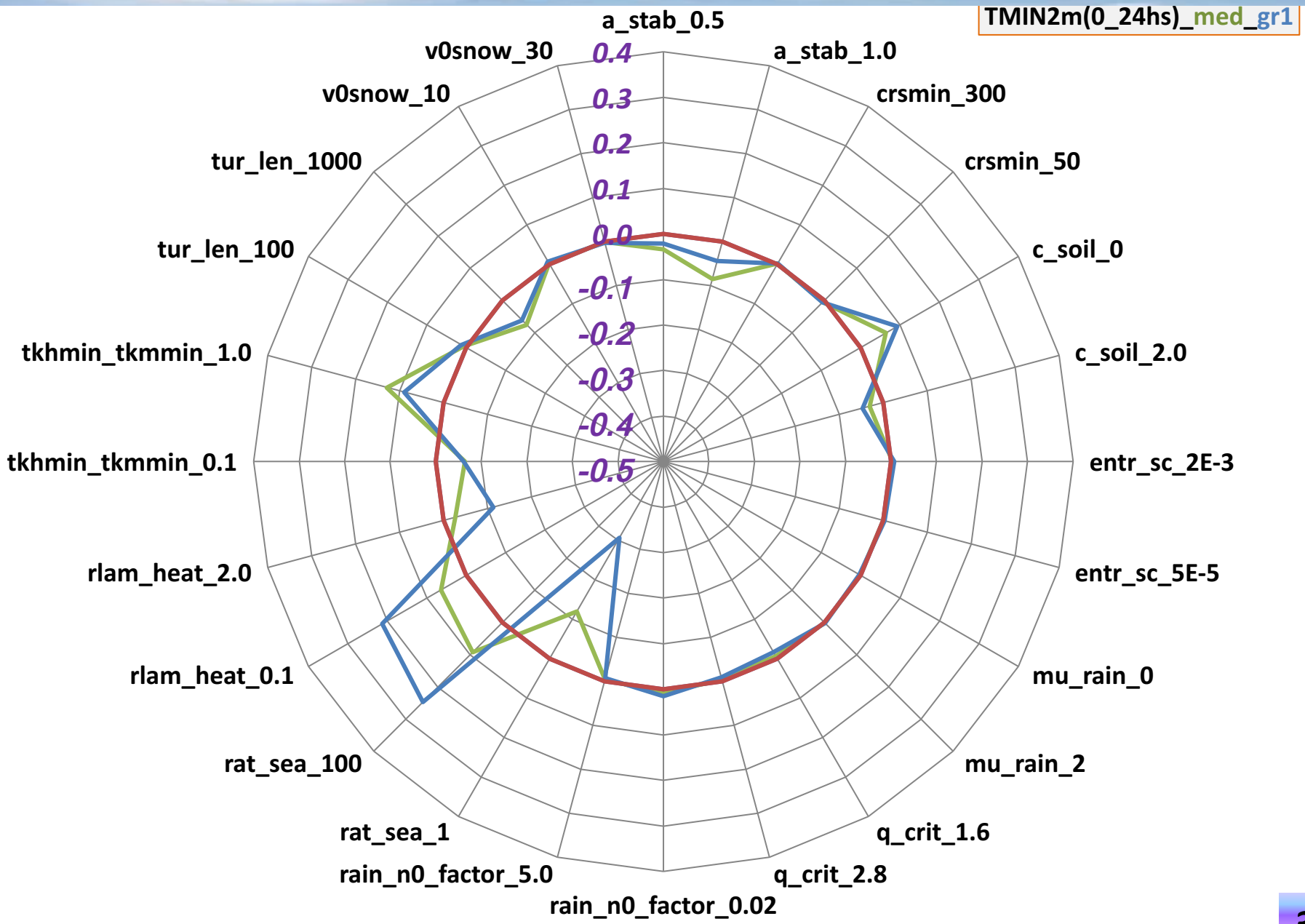




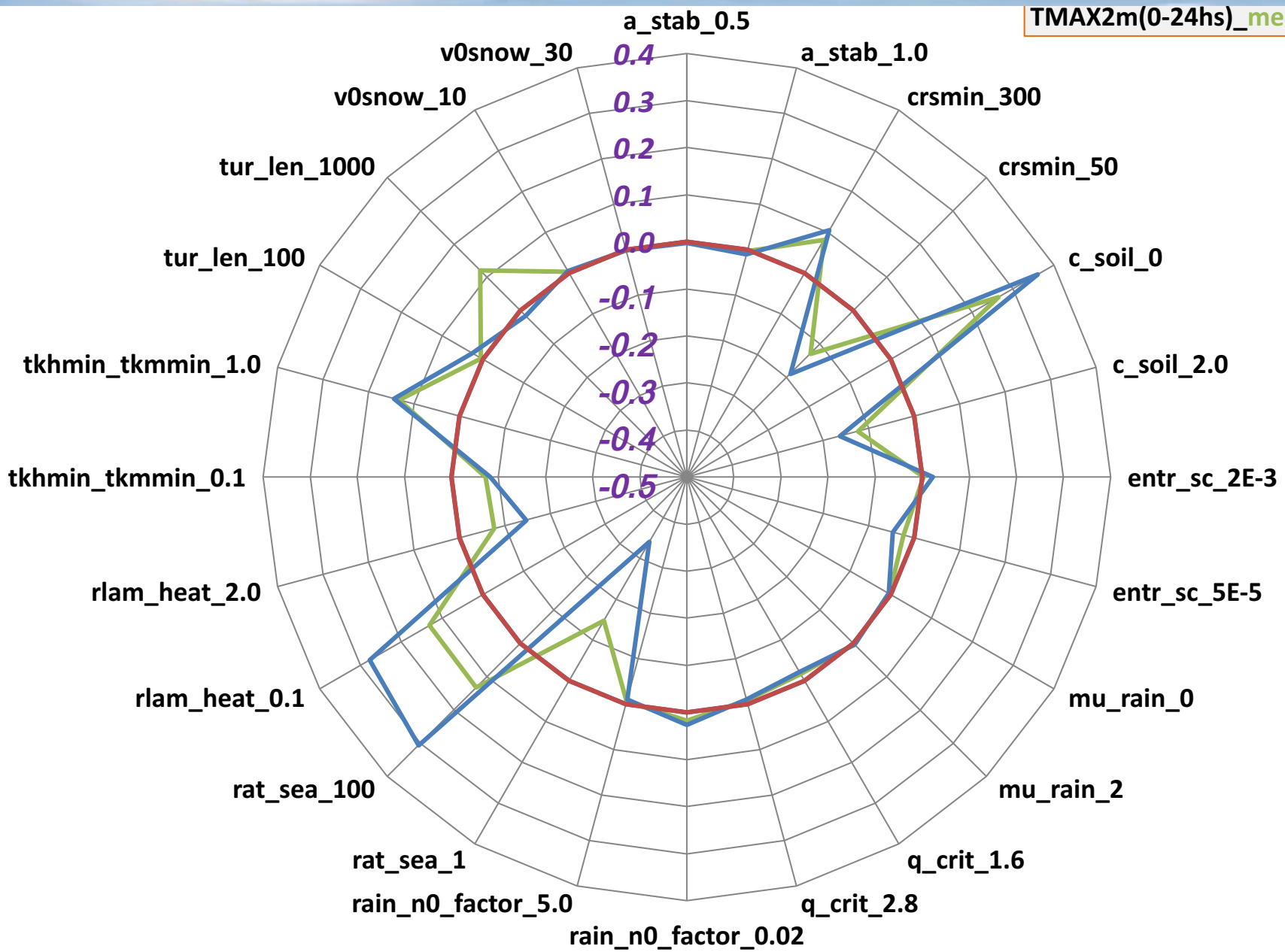
Sensitivity (%) for TOTPREC MED.vs.GR1



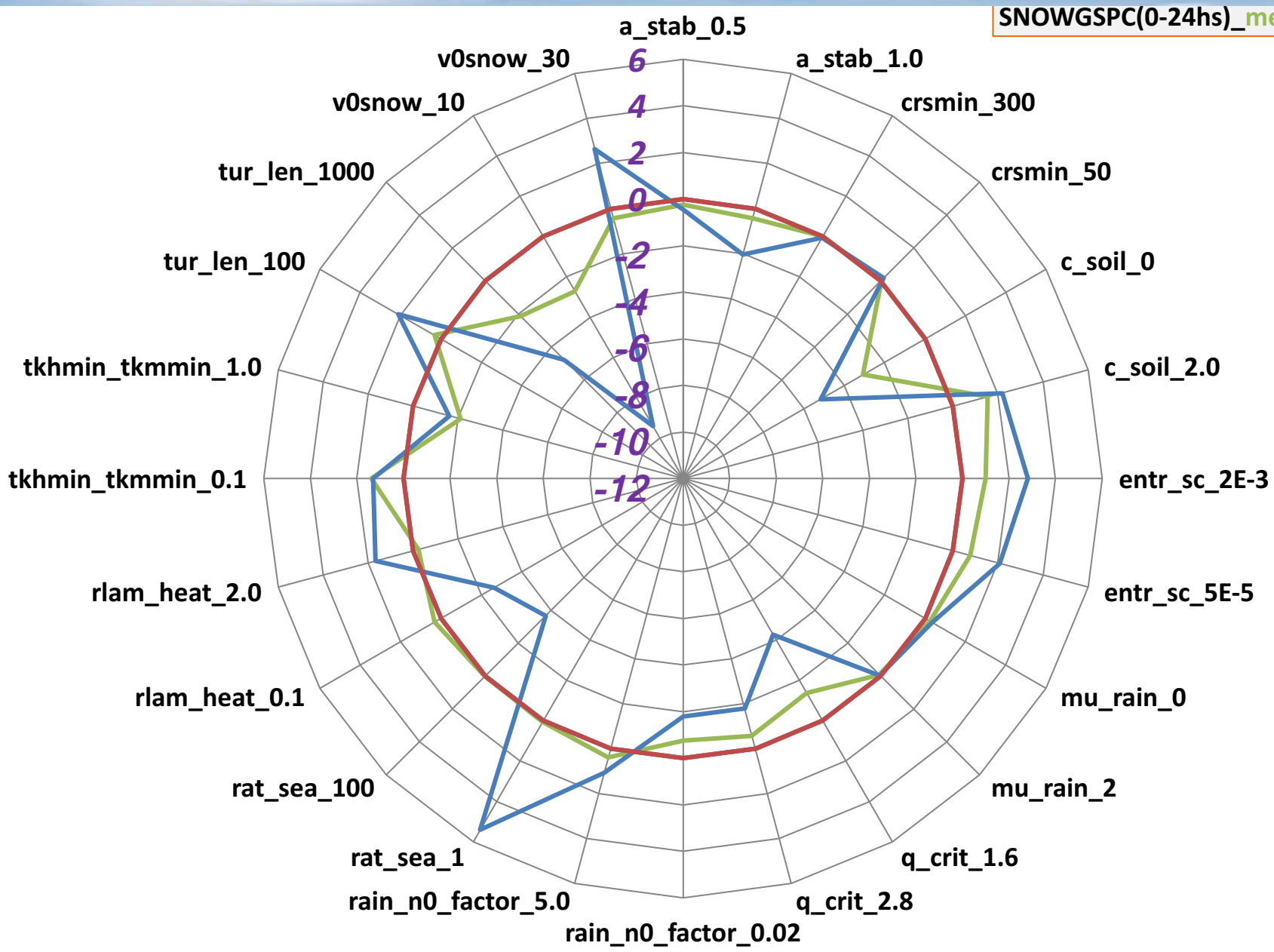
Sensitivity (degs) for TMIN2m MED.vs.GR1



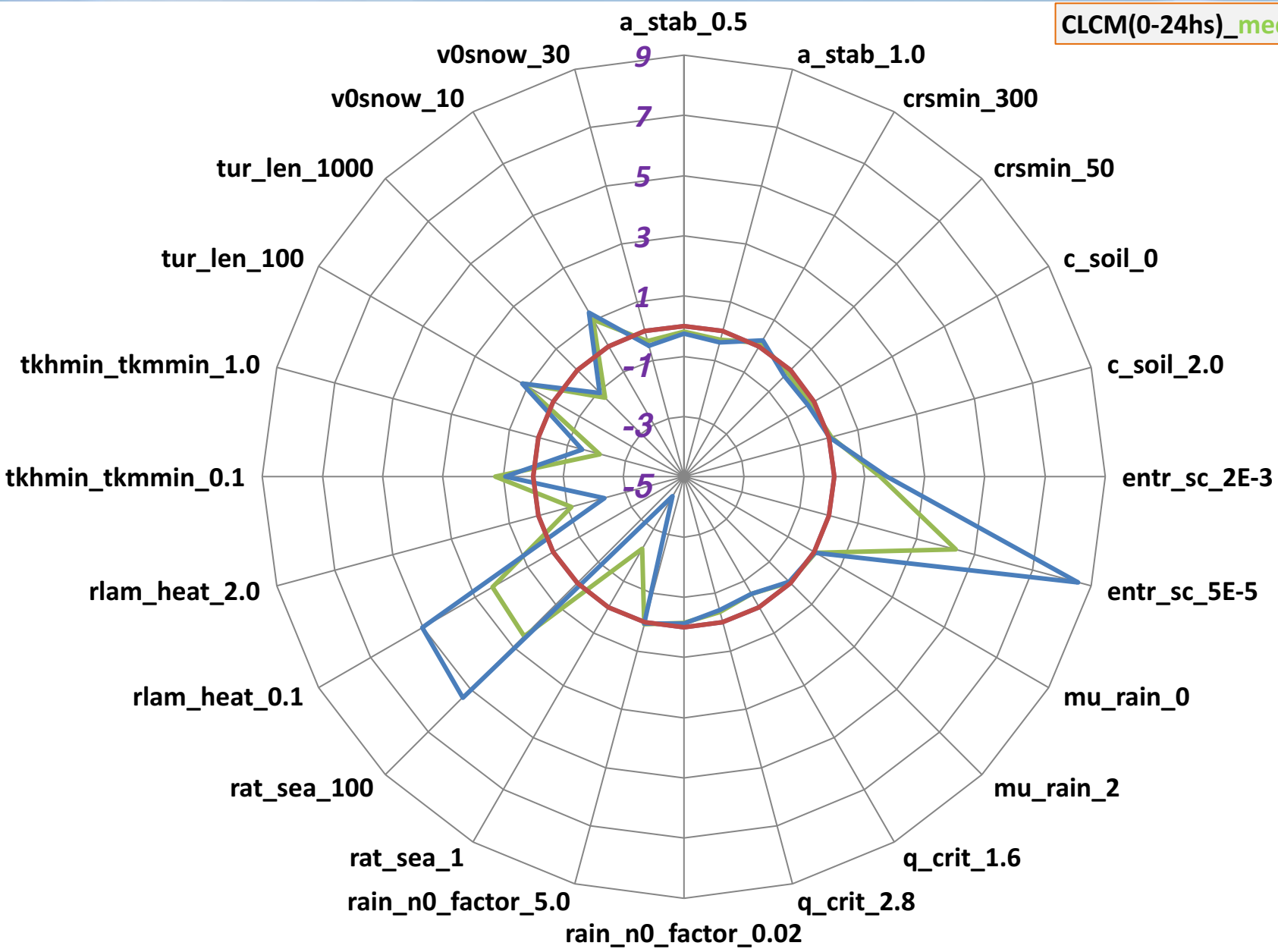
Sensitivity (degs) for TMAX2m MED.vs.GR1



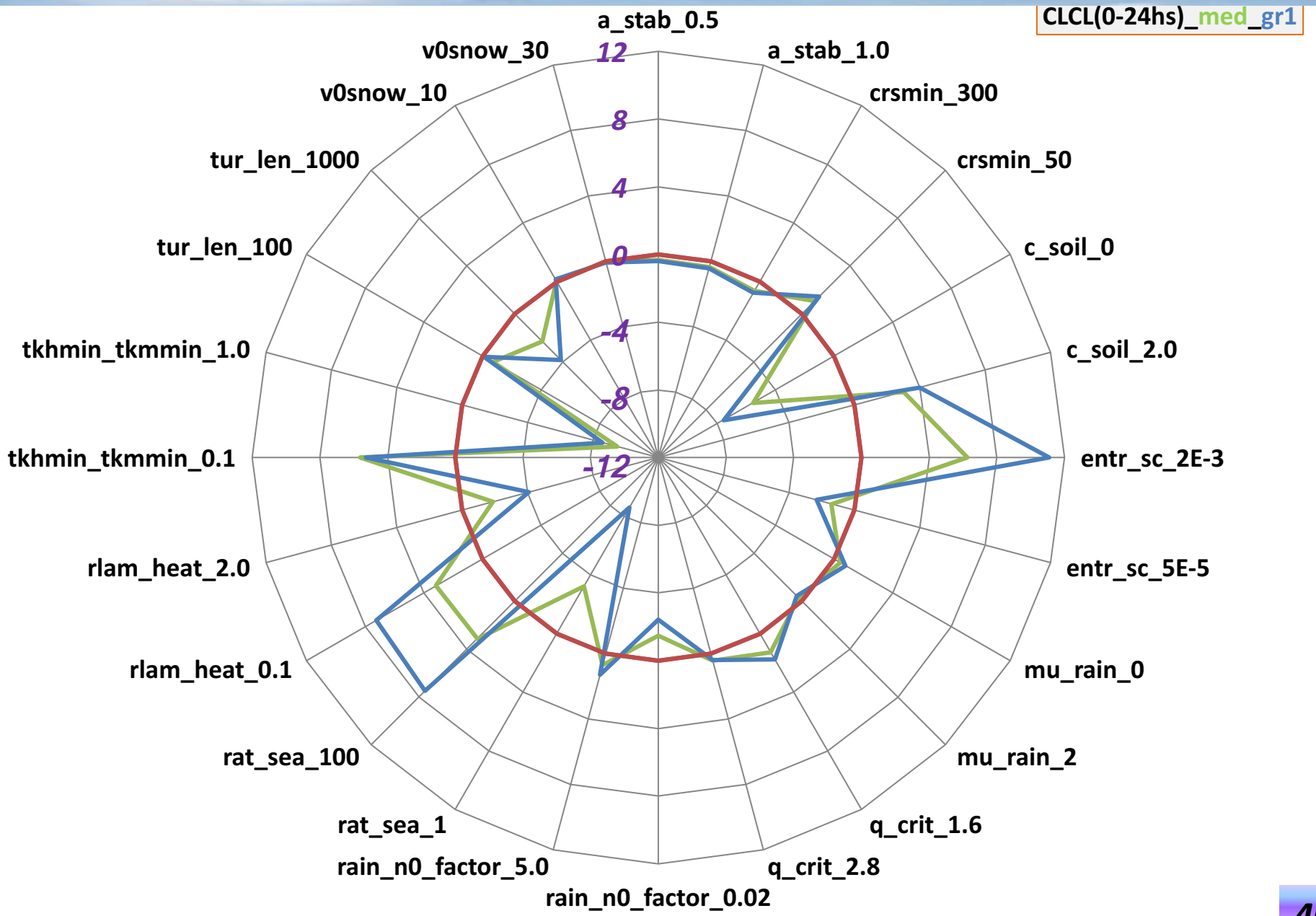
Sensitivity (%) for TOTPREC MED.vs.GR1



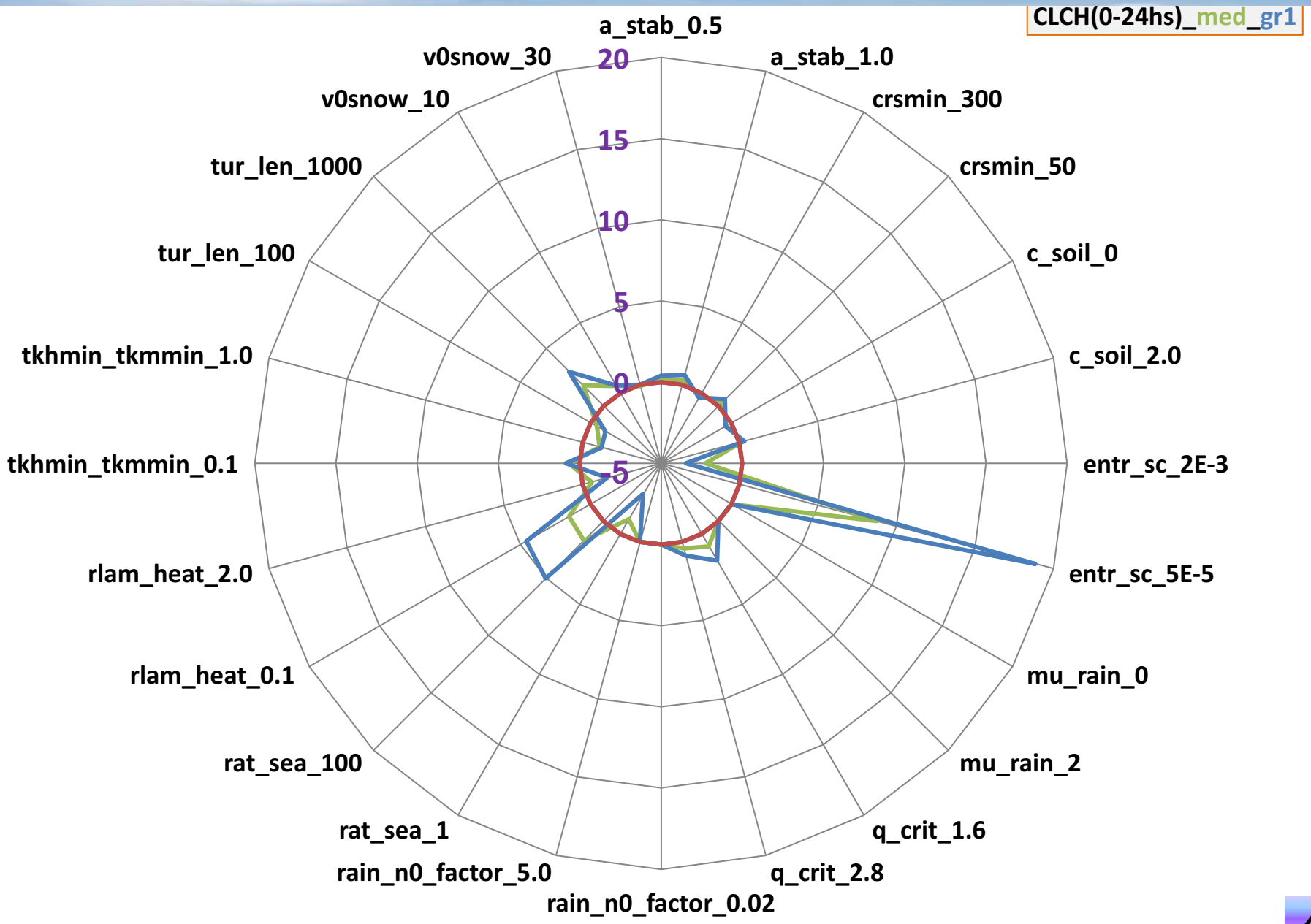
Sensitivity (%) for CLCM MED.vs.GR1



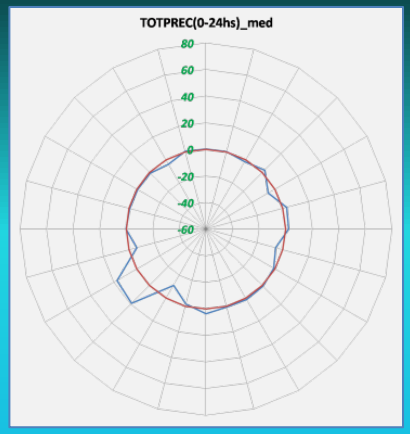
Sensitivity (%) for CLCL MED.vs.GR1

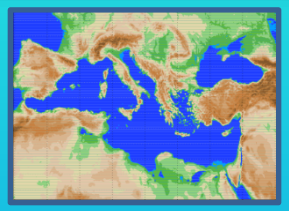


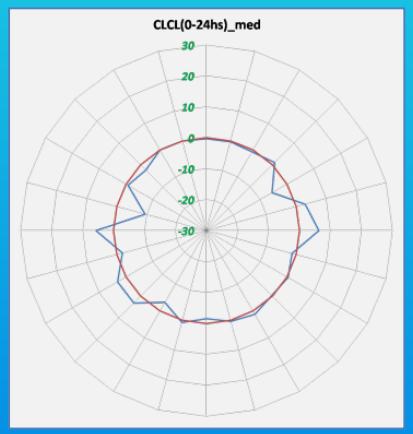
Sensitivity (%) for CLCH MED.vs.GR1

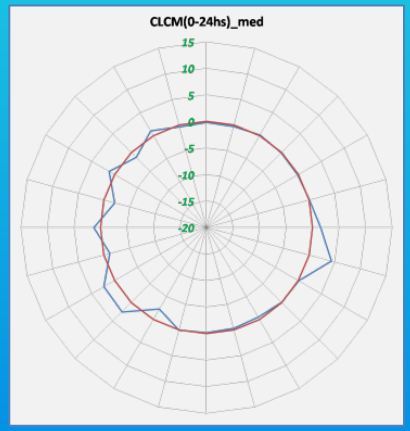


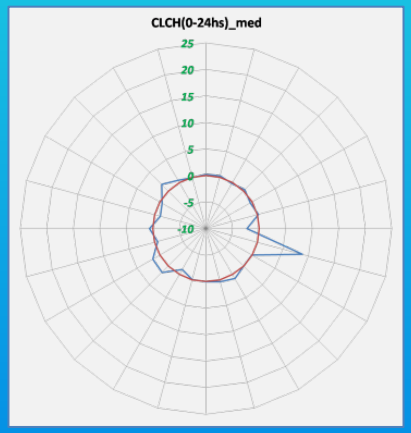
Sensitivities for MED

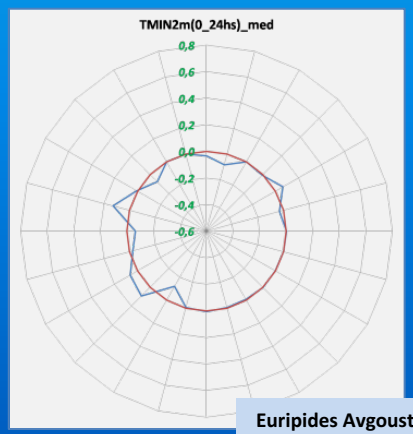


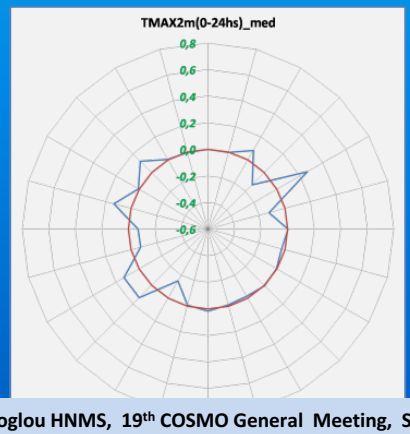


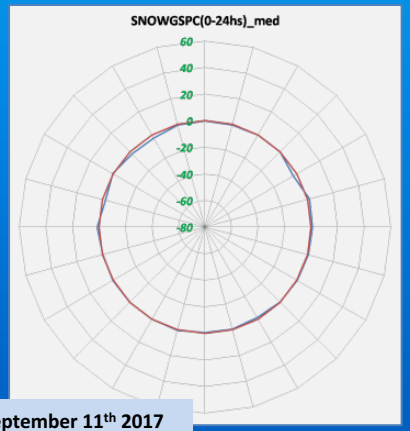




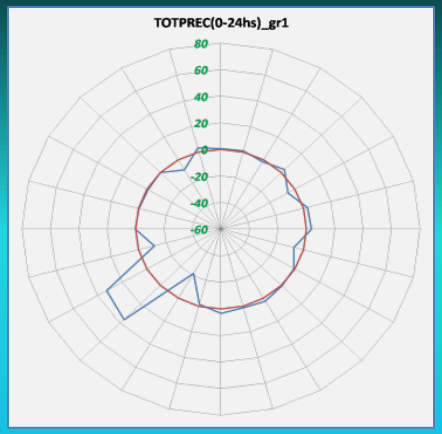


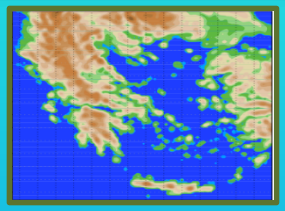


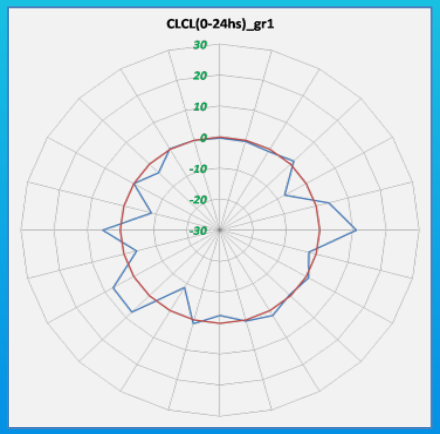


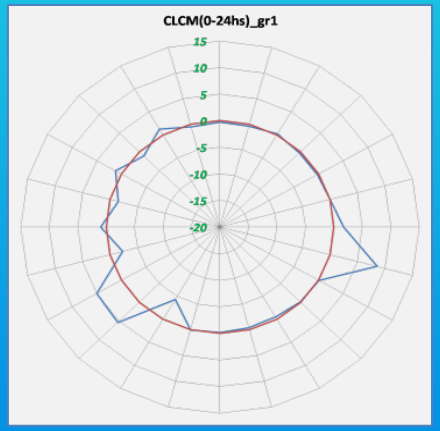


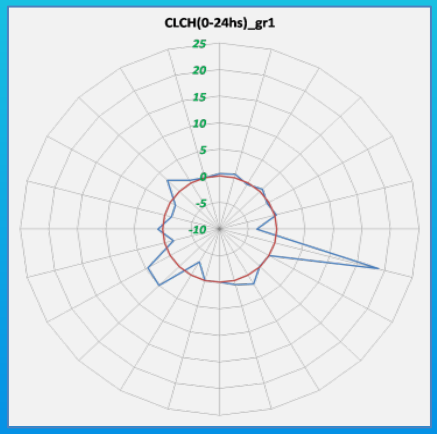
Sensitivities for GR1

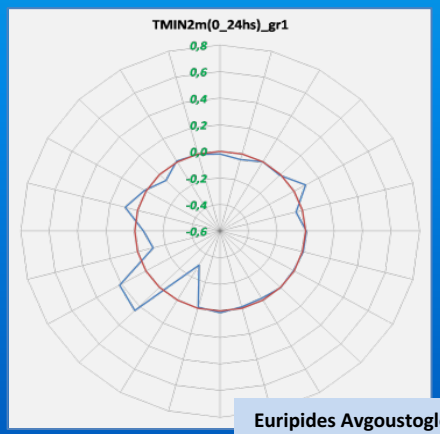


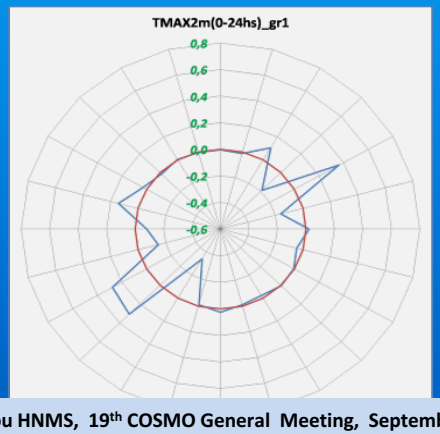


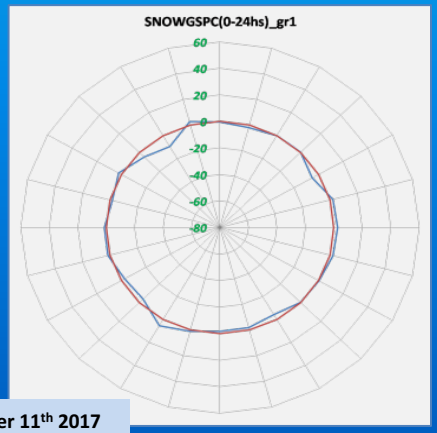




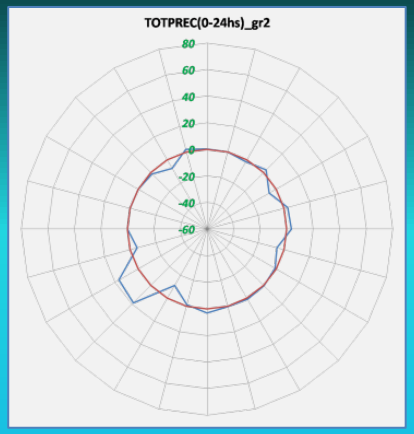


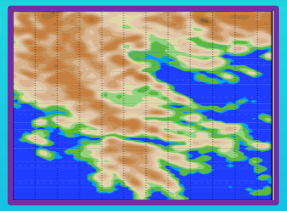


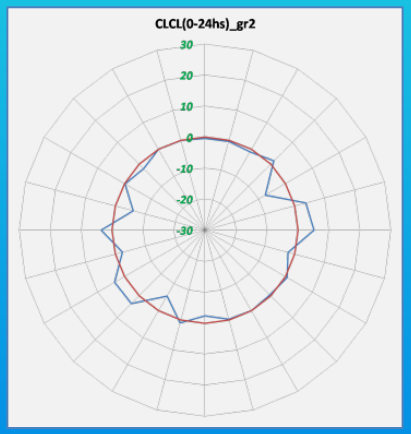


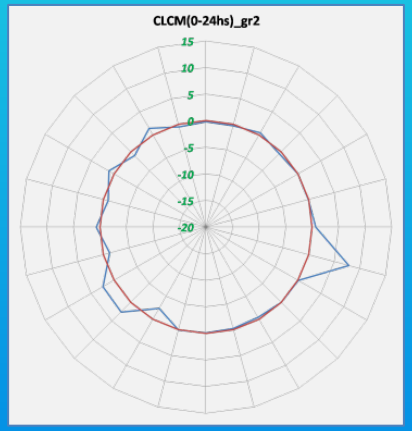


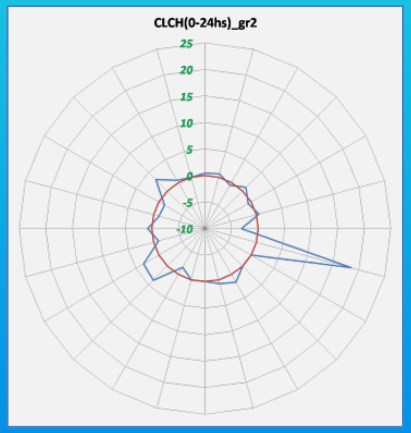
Sensitivities for GR2

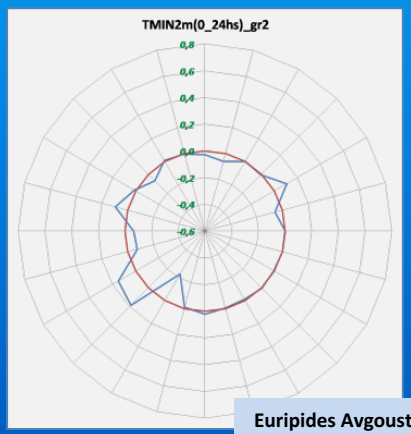


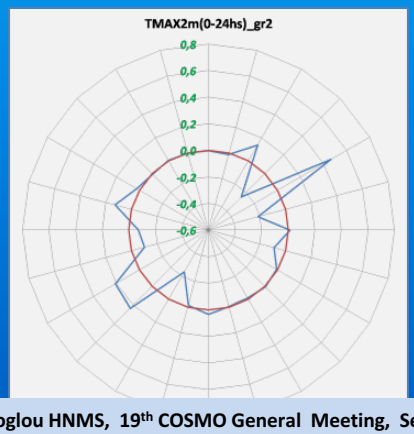


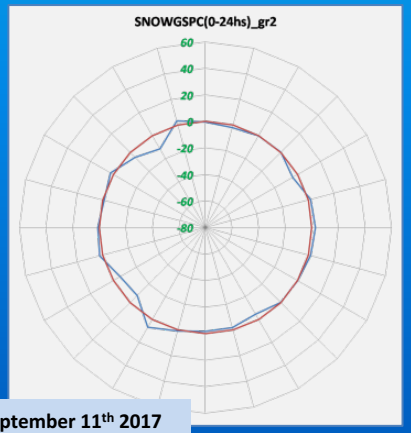




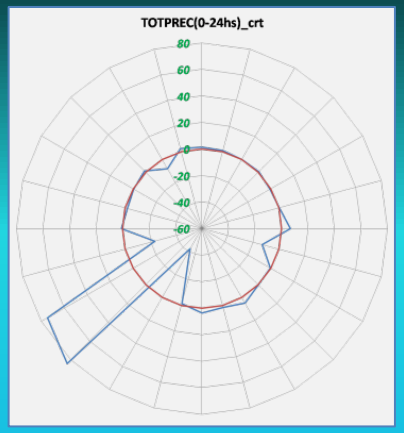


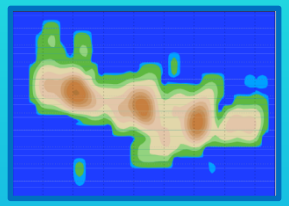


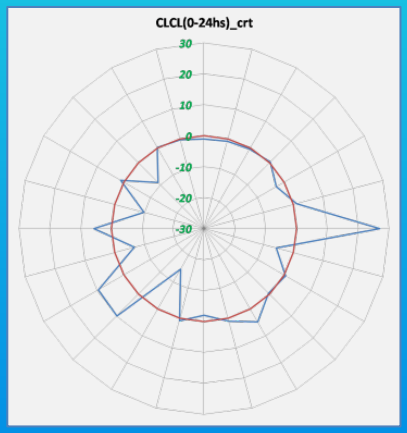


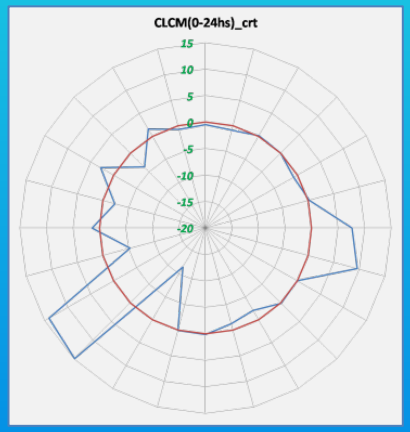


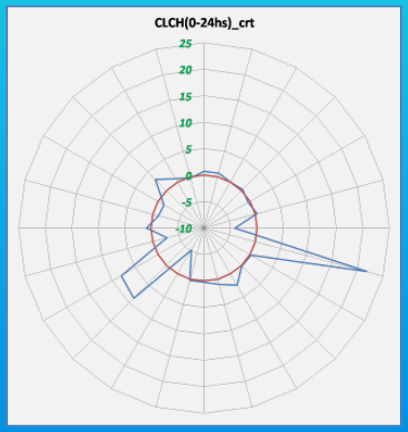
Sensitivities for CRT

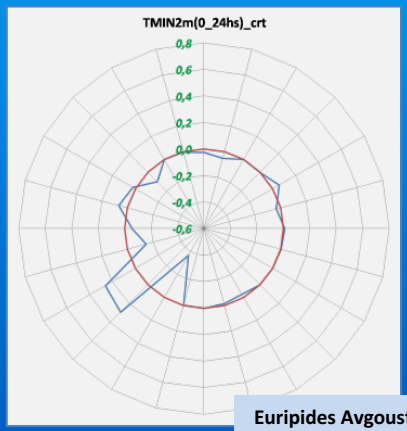


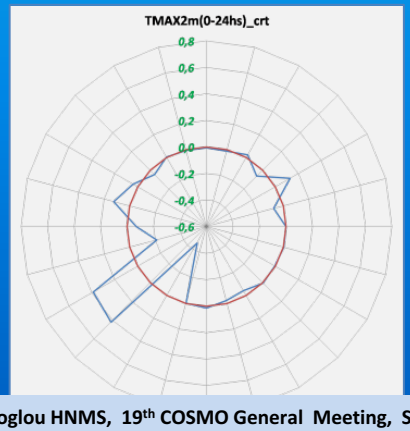


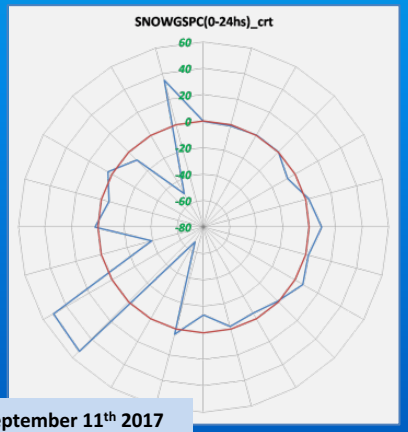




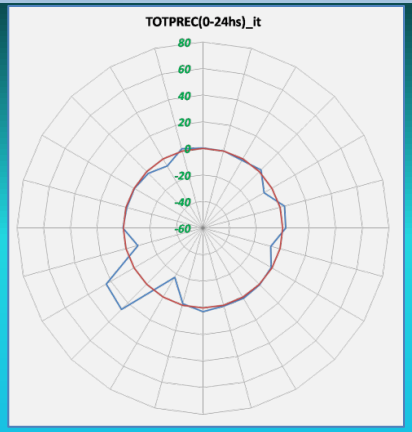


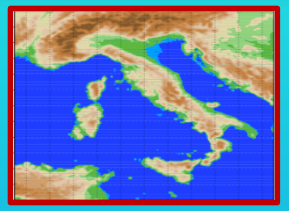


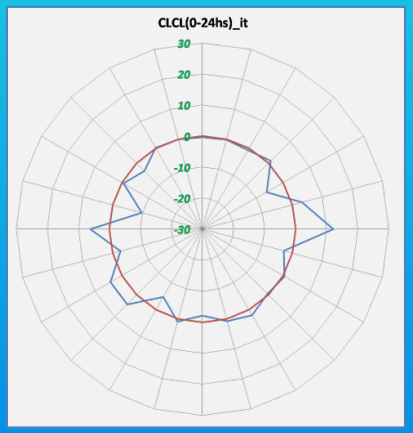


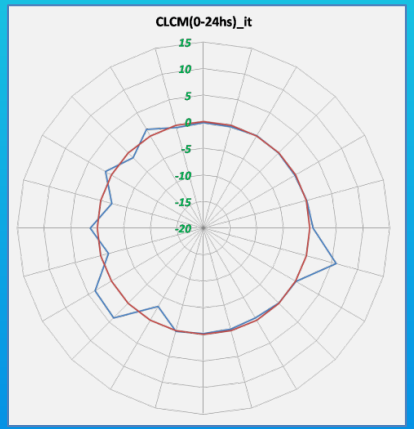


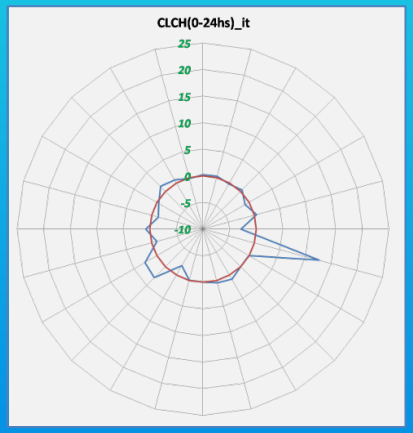
Sensitivities for IT

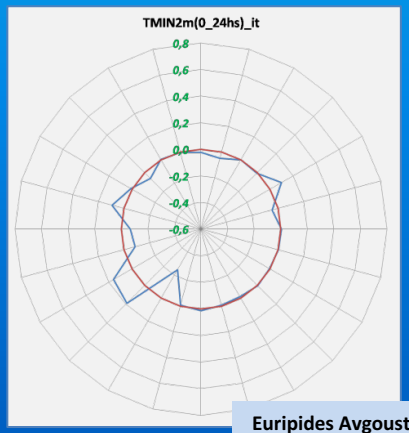


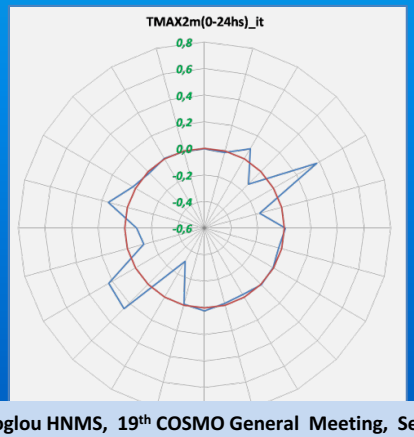


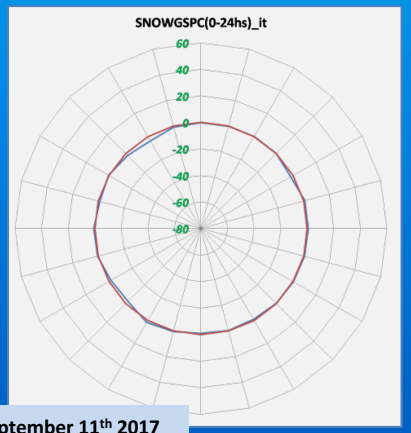




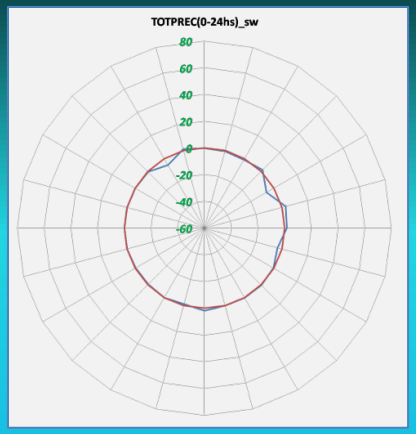


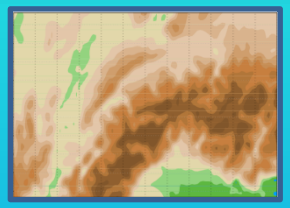


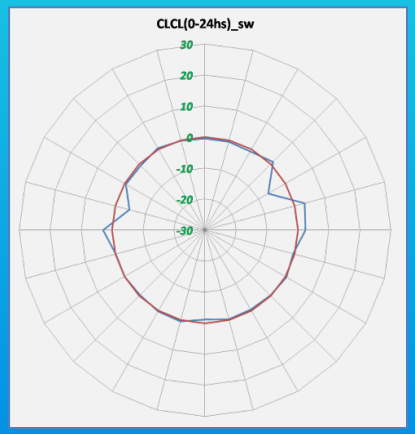


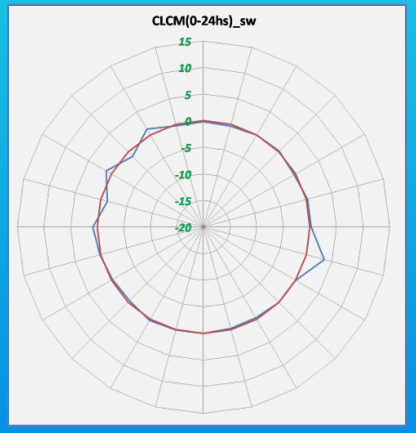


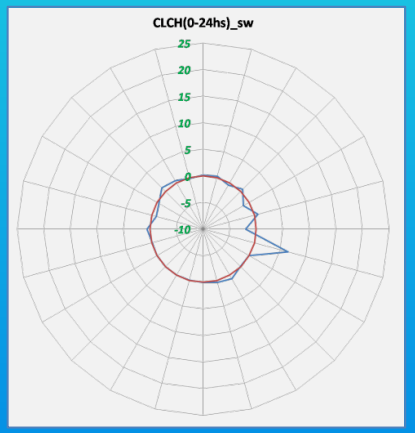
Sensitivities for SW

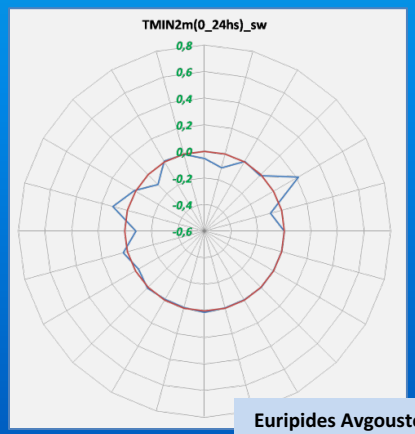


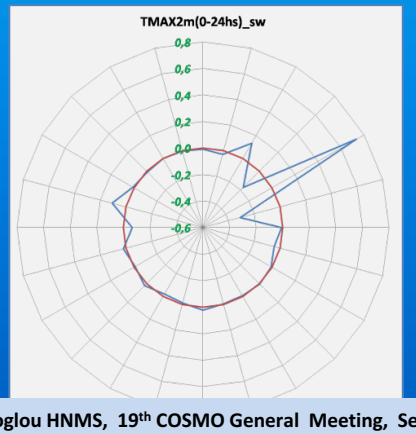


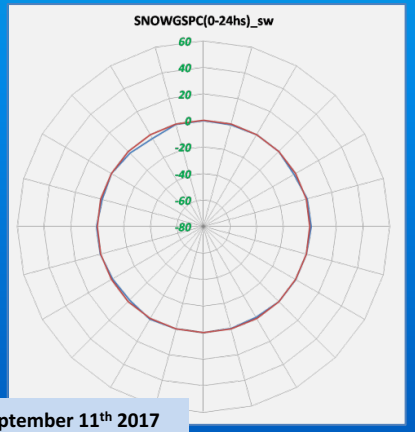




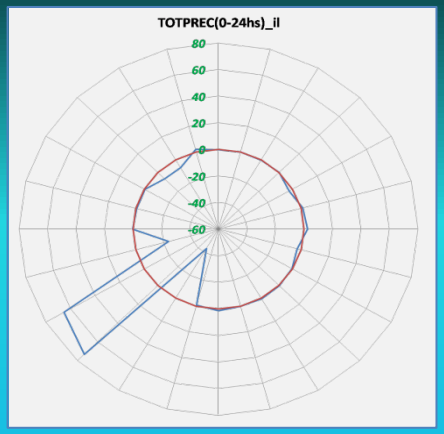


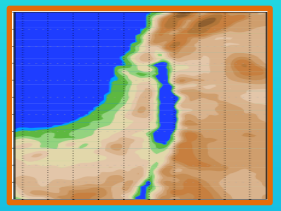


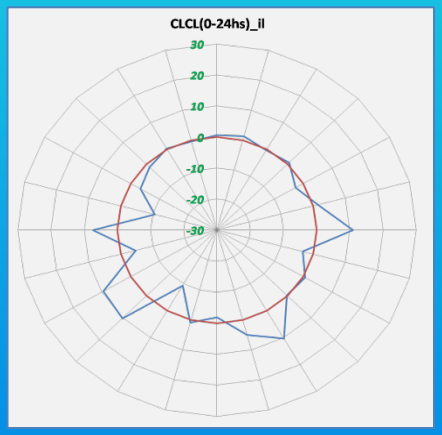


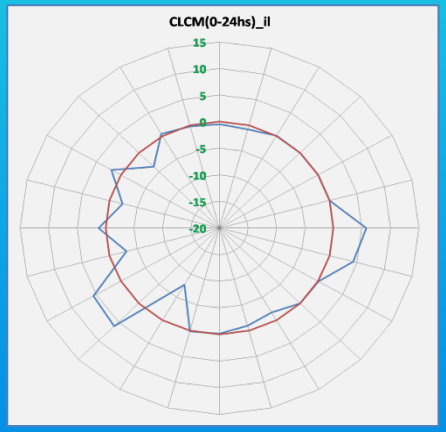


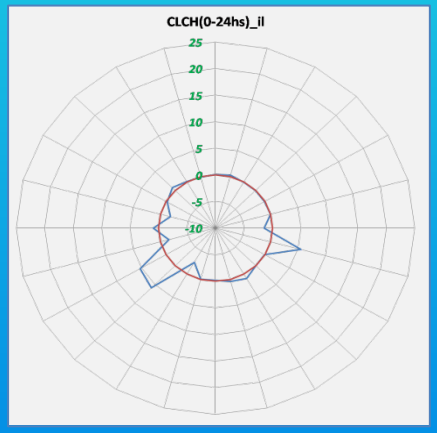
Sensitivities for IL

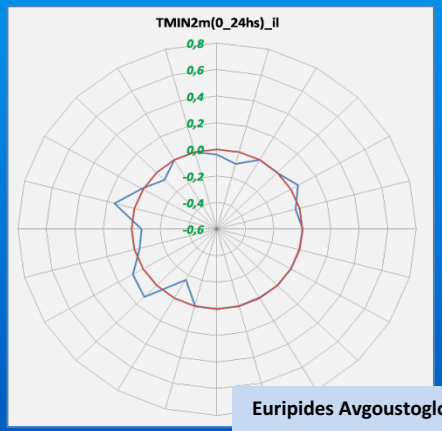


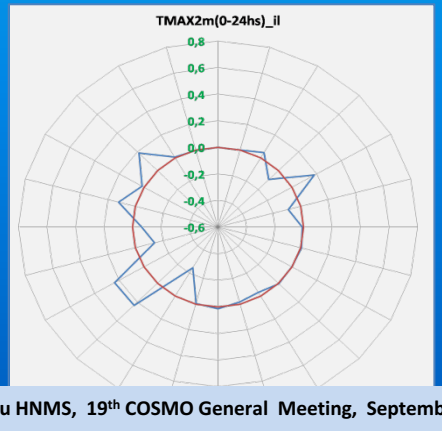


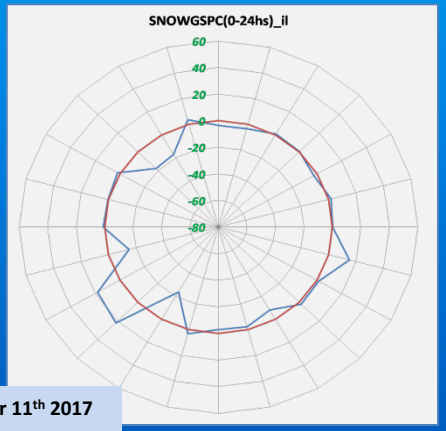








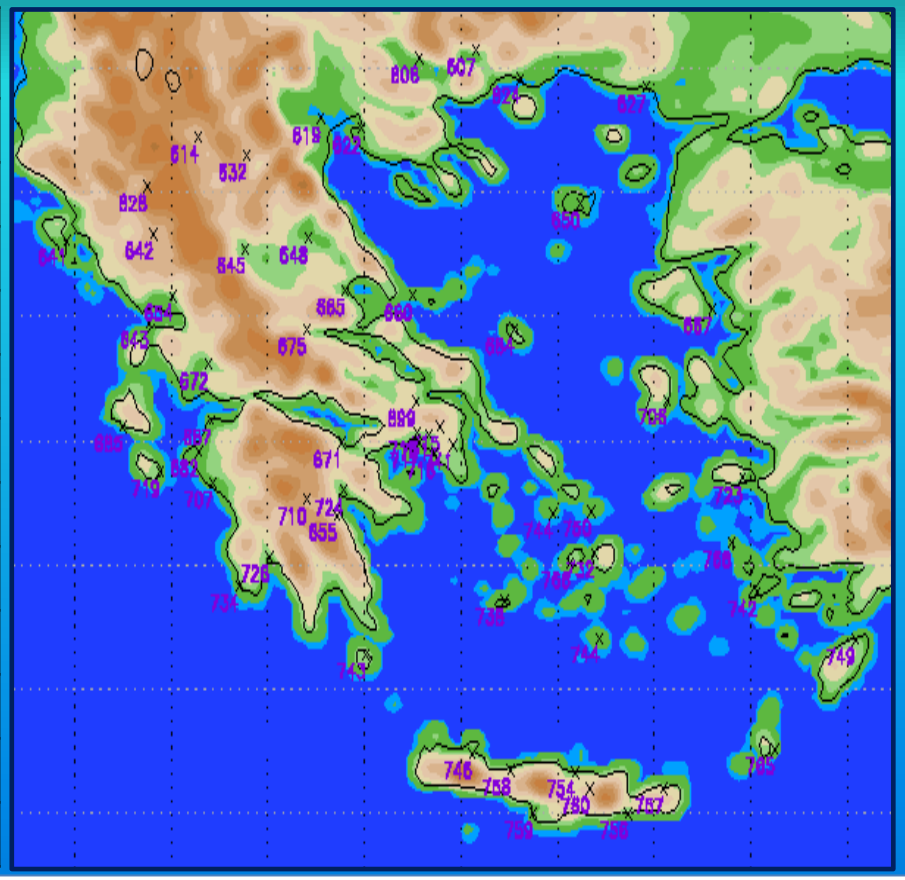




COMPARISON WITH OBSERVATIONS

From the previous analysis *rat_sea* and *rlam_heat* parameters along with the corresponding sets of runs were considered suitable for comparison with observations:

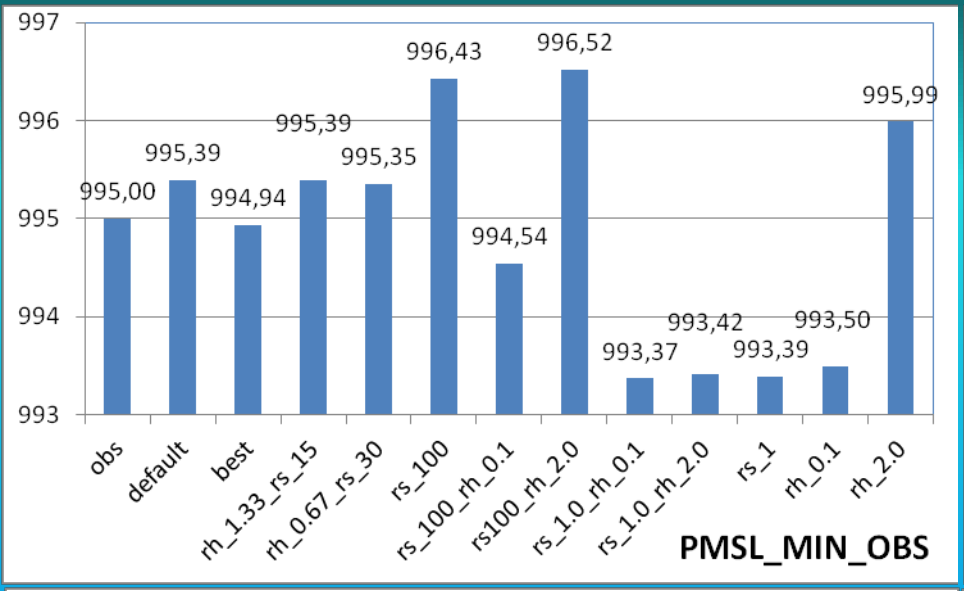
test name	rat_sea	rlam_heat
default	20	1.0
calmo2_best*	15.71	1.13
rh_1.33_rs_15**	15	1.33
rh_0.67_rs_30**	30	0.67
rs_100	100	1
rs_100_rh_0.1	100	0.1
rs100_rh_2.0	100	2.0
rs_1.0_rh_0.1	1.0	0.1
rs_1.0_rh_2.0	1.0	2.0
rs_1	1.0	1.0
rh_0.1	20	1.0
rh_2.0	20	2.0

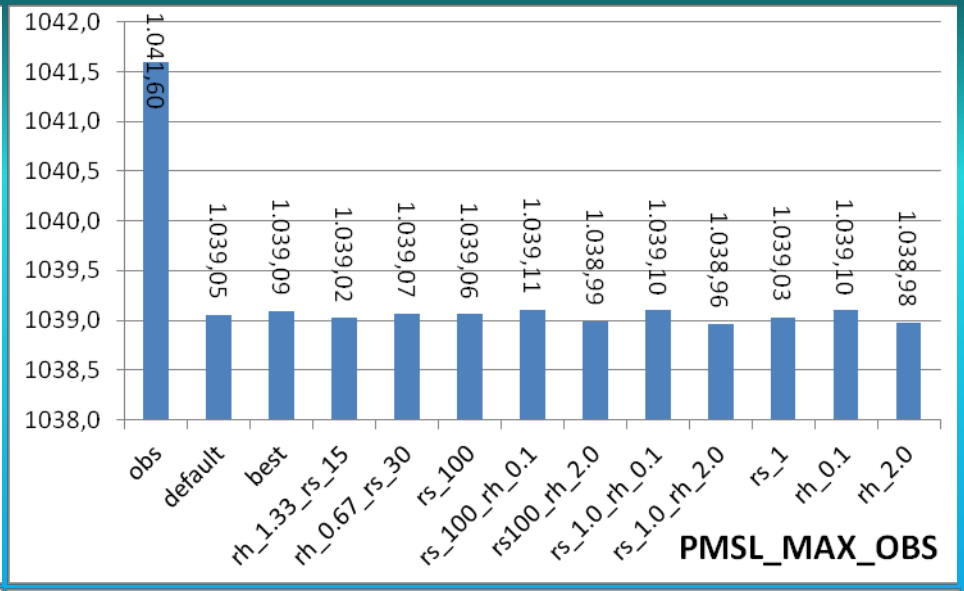


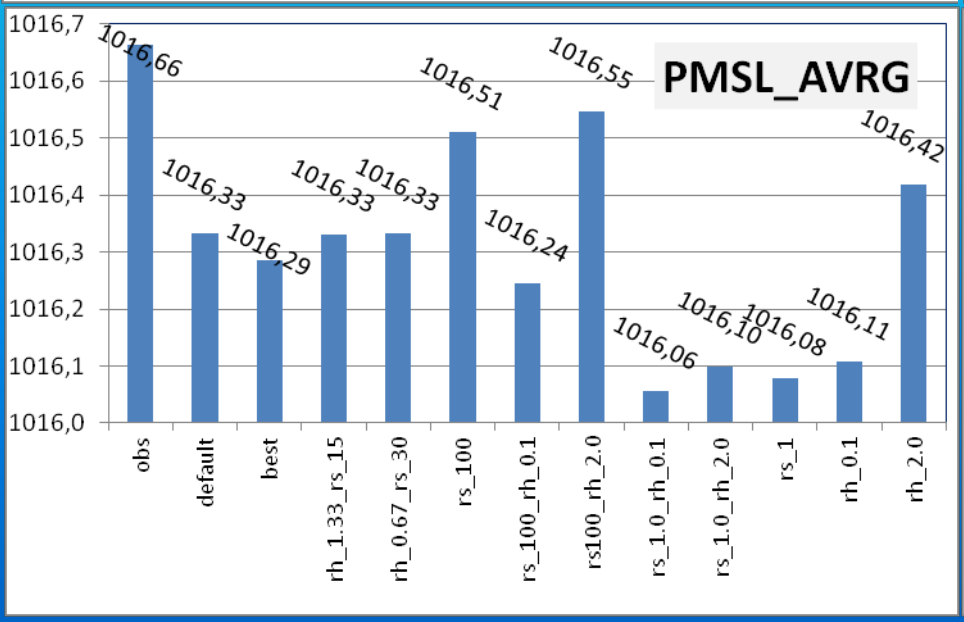
*CALMO2 optimum values, i.e: v0svow=12.3, c_soil=0.588, entr_sc=0.0001607, tu_len=346.5, tkhmin=tkmmin=0.266

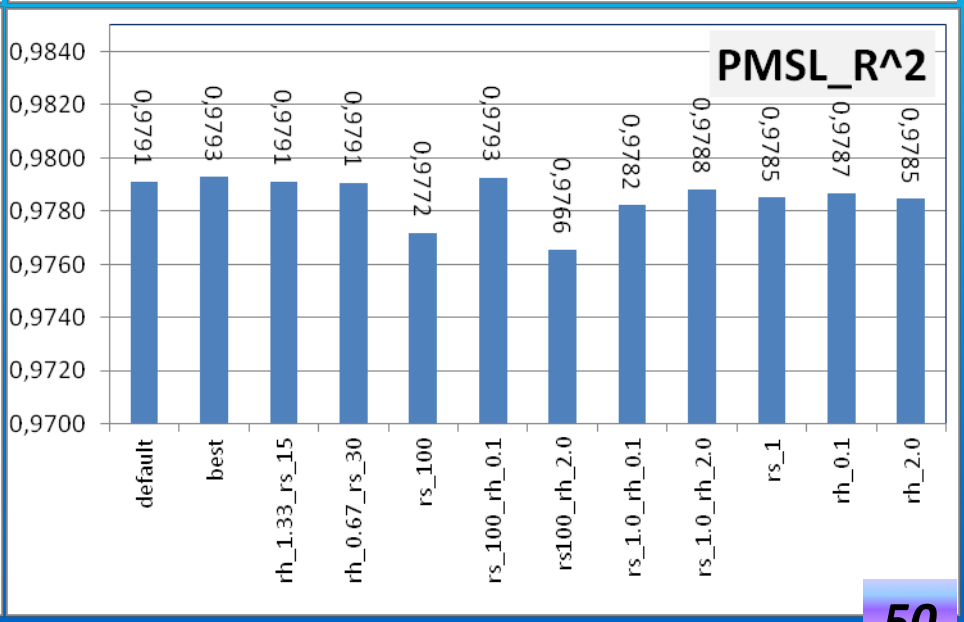
$$**\ rat\_sea_{\_test} \bullet rlam\_heat_{teat} = rat\_sea_{\_default} \bullet rlam\_heat_{\_default} = 20.0 \bullet 1.0 = 20.0$$

PMSL (Approx. 20000 Observations/50 Stations)

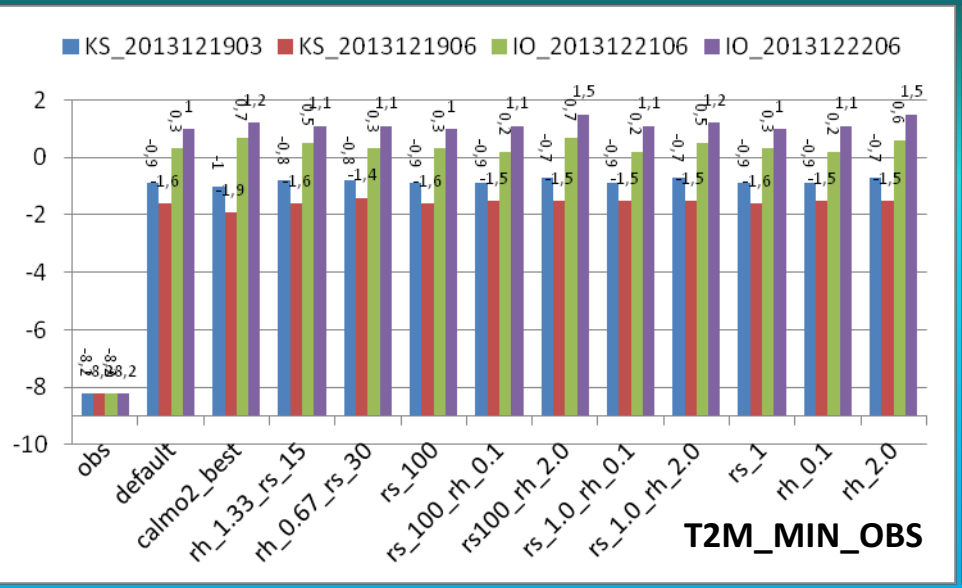


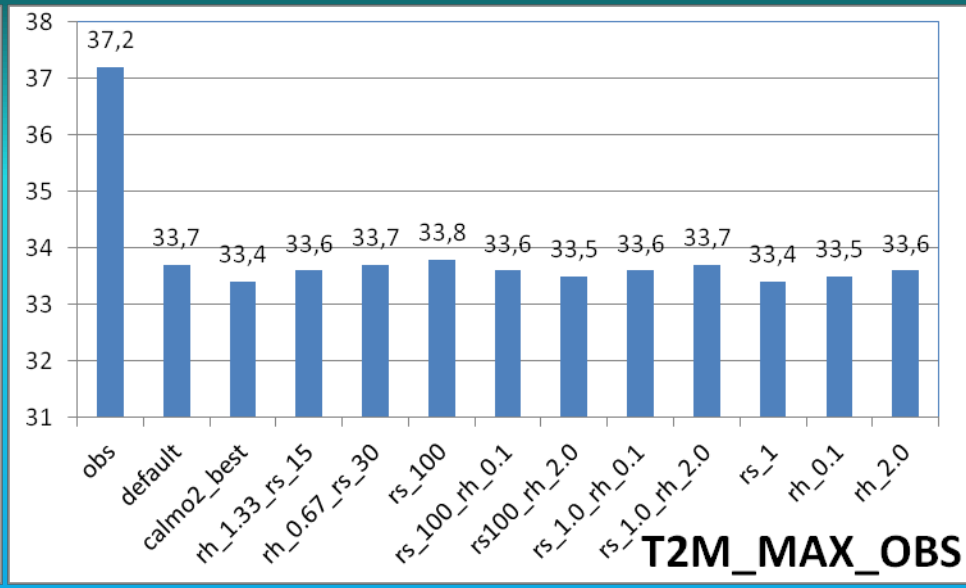


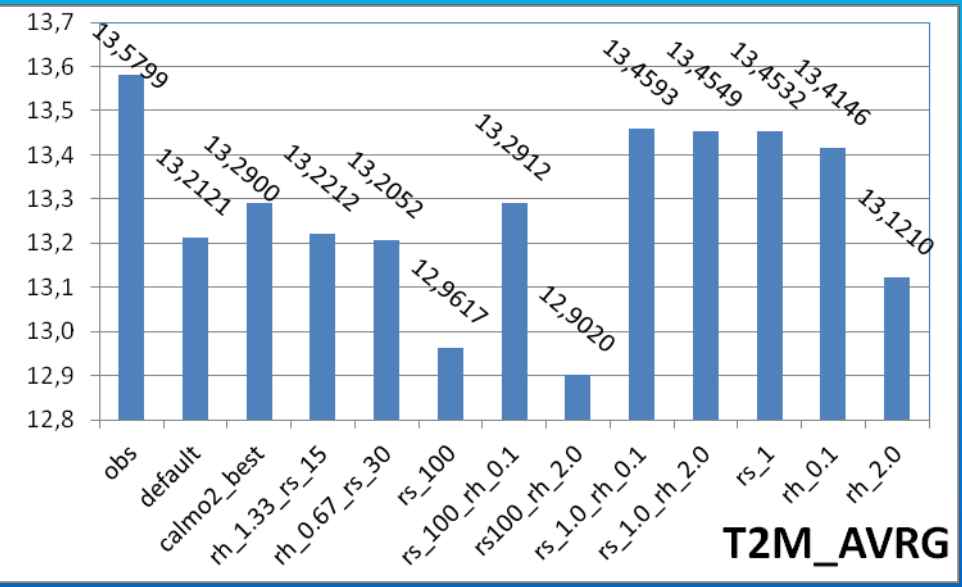


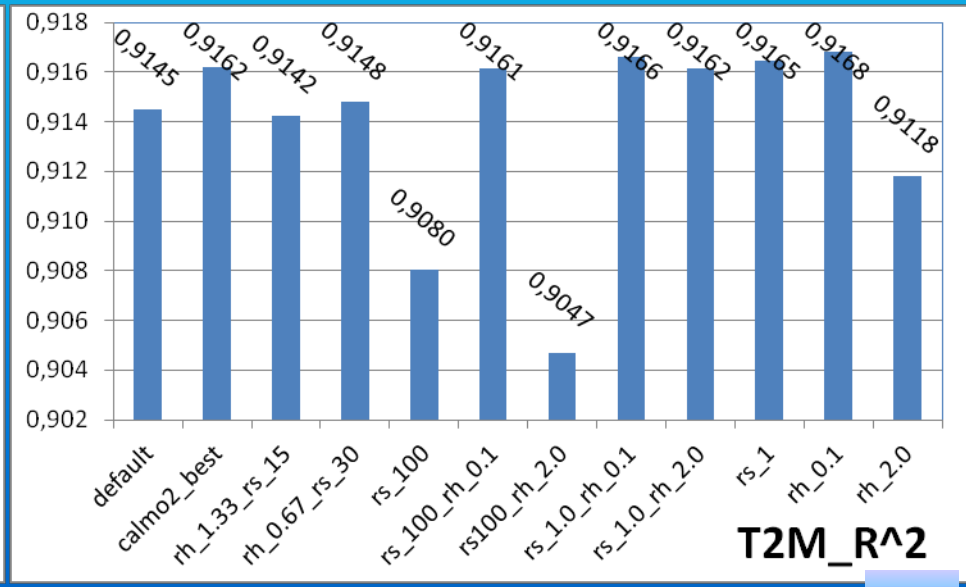


T2M (Approx. 16000 Observations/40 Stations)

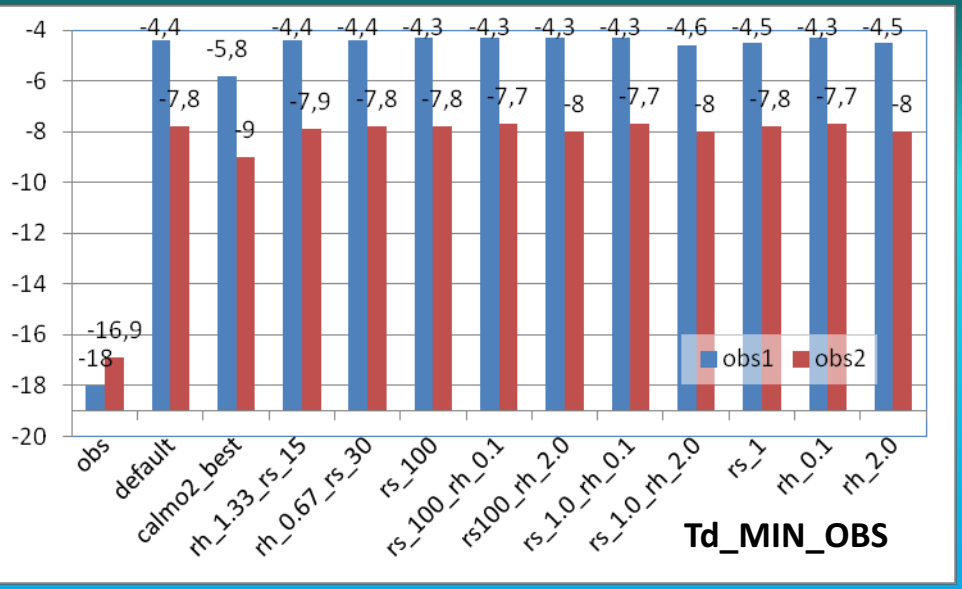


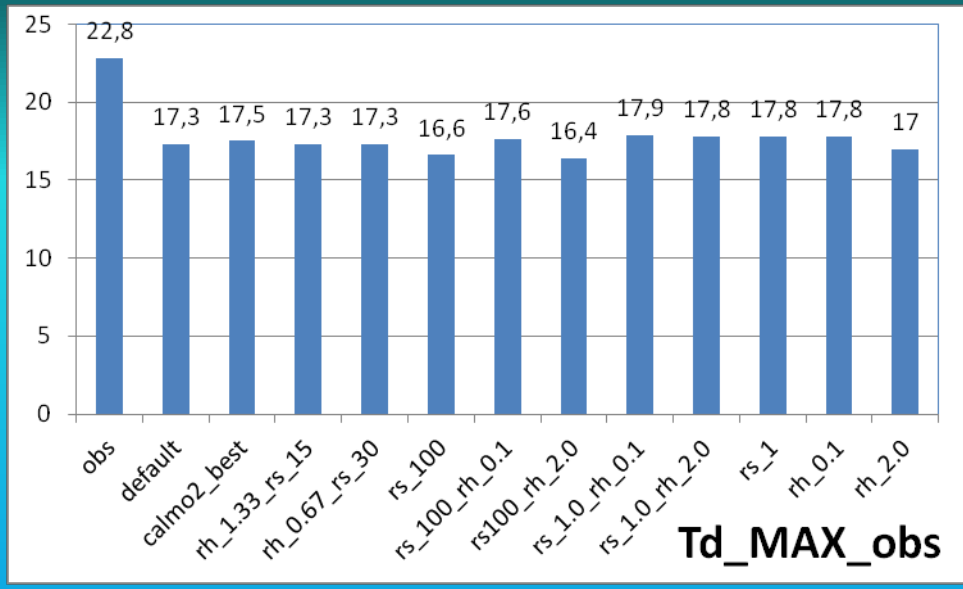


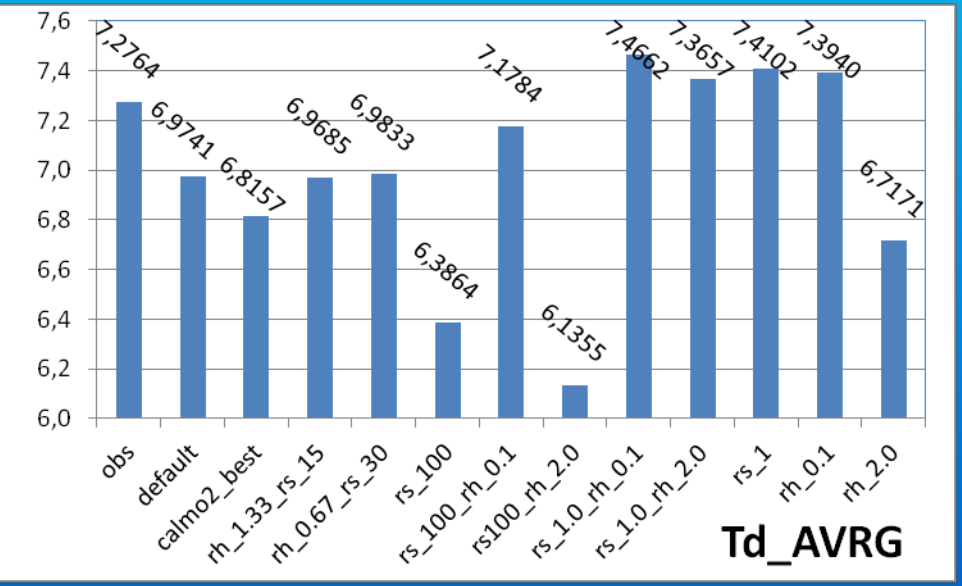


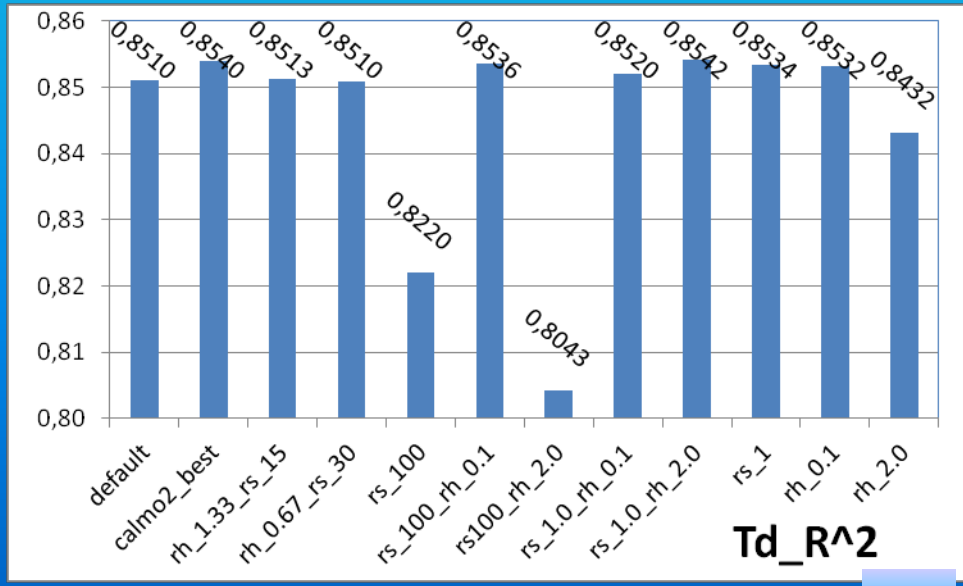


Td (Approx. 16000 Observations/40 Stations)

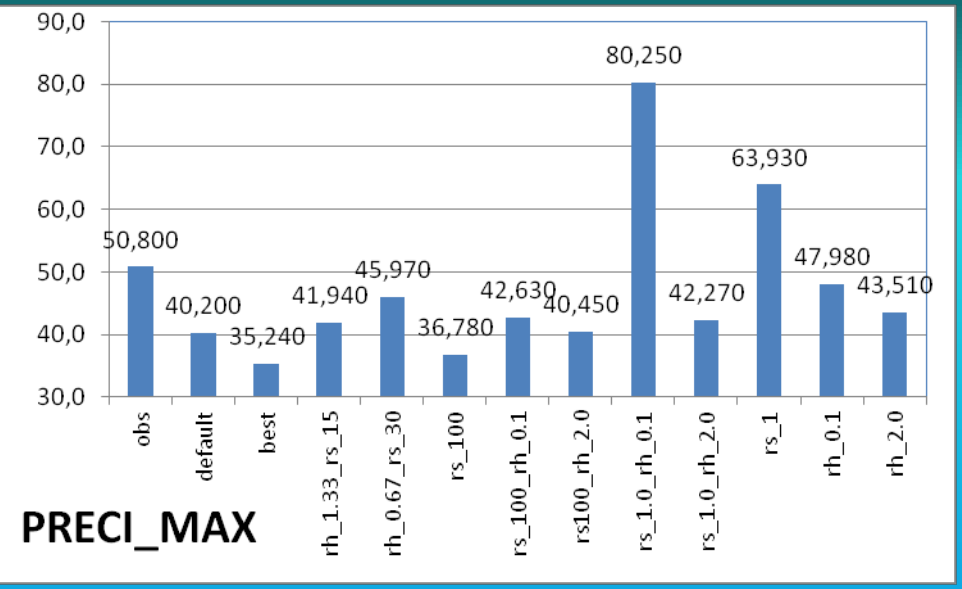


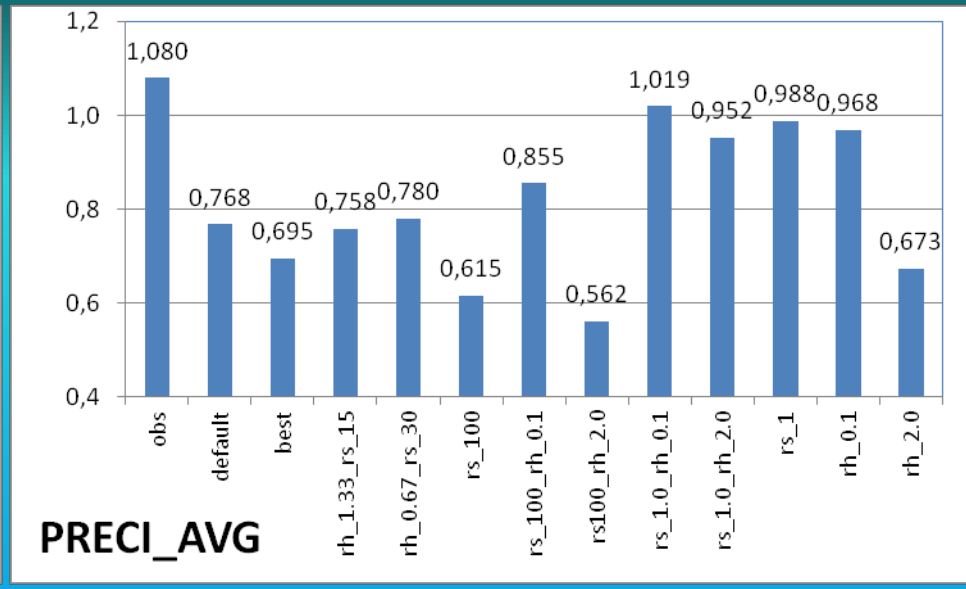


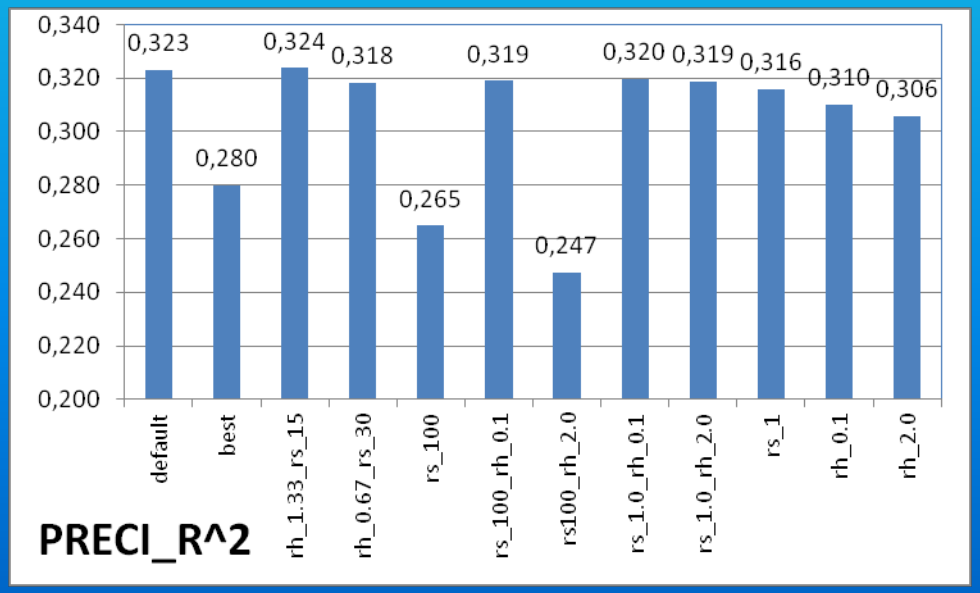




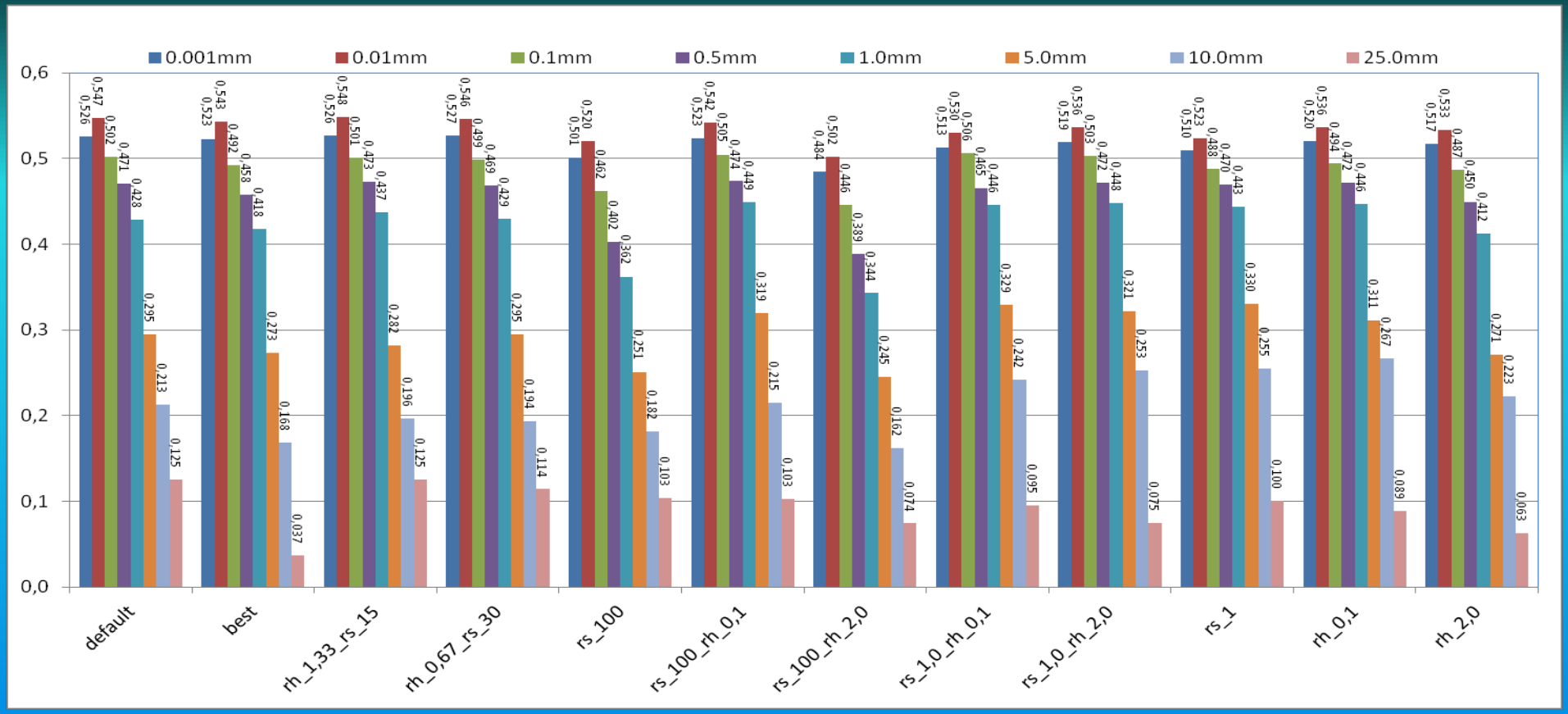
12hr PRECIPITATION (Approx. 5500 Observations/50 Stations)







12hr PRECIPITATION **T**hreat **S**core (Approx. 5500 Observations/50 Stations)



$$TS = \frac{Hits}{Observations + Fales\ Alarms} \bullet 100$$

Hits are cases where observed and forecasted precipitation is greater or equal to a threshold value.
Observations are cases where observed precipitation is greater or equal to the threshold value.
FalseAlarms are cases where the observed precipitation is smaller than the threshold value and forecasted precipitation is greater than the threshold value.

CONCLUSIONS

- Similar sensitivity patterns can be considered a factor regarding the choices of parameters to be tested.
- COSMO model provided meaningful results even for the limit parameter values.
- Even if the heuristic choice of certain parameter values looks statistically as a fair approach, model optimization remains an important issue and the meta-model should be the way to go.

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- COSMO2 _best is at least on a par with the default runs for the domain of Greece.